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Ophthalmological Implications for the Early History of the Snakes

By Gordon L. Walls

IT HAS long seemed strange that the eyes of snakes should differ so much from those of lizards, considering the closeness of relationship of the two groups. Indeed, the ophidian eye exhibits not one solitary structural feature which would enable a comparative ophthalmologist, handed a microscopic preparation of it, to place its owner in the Sauropsida at all.

Other reptiles, and birds, have so much in common ophthalmologically that it can be said truly that the eyes of snakes are as different from those of other Sauropsida as mammalian eyes are from those of amphibians. The situation fairly cries out for an interpretation, though none has hitherto been offered except the rather lame one that the snake's eye is so built as to suit his way of life. This hardly explains why the snake should have so completely revolutionized the ocular schema of his lizard ancestors, when the way of life of the average snake is so much like theirs. Franz (1934) has given excellent morphological accounts of standard lizard and snake eyes. Abstracted briefly with minor revisions, they will serve to delineate the problem whose solution it is proposed to offer here:

The typical lizard eye (Fig. 1) stands roughly intermediate between those of *Sphenodon* and the birds. It exemplifies the predominance of diurnal adaptation among reptiles, which were the first vertebrates to feel fully the strain of maintaining high locomotor activity while supporting all of their considerable weight on land, and consequently became sun-worshippers and remained such until the dwindling of body size permitted, and the advent of enemies necessitated, the secondary adoption of nocturnality by scattered groups and single genera.

In shape it is a rotation-ellipsoid, with the optic axis the shortest diameter and with more or less horizontal ellipticity which extends the visual angle in the horizontal plane. The scleral portion of the fibrous tunic is supported by a cup-like cartilage which traces back to the fishes and forward into the birds and mammals, and the convex curvature of the sclero-corneal junction is altered to a conical or even concave form by a ring of shingle-like bony plates, the scleral ossicles, which are almost universal in Sauropsida and are probably homologous with the periorbital bones of fishes. The iris merges into the chorioid coat through a broad ciliary body which is exceptional in being devoid of folds, or "ciliary processes."

The lens is soft—though firmer than in turtles (softness going with deformability in accommodation)—and is 1.4 to 1.5 times as broad as it is thick, the flat form being associated with high visual acuity since it makes for a large retinal image. A fifth of the radius of the lens is taken up by the annular pad or "Ringwulst," a peculiarly sauropsidan feature which plays no part in the formation of the image since it is shielded by the iris even when the pupil is widely open. Meridional, striated muscle fibers of mesodermal origin, lying in the ciliary body and inserting in its base plate and in the inner lamellae of the cornea, constitute a protractor muscle. Its contraction stretches the ciliary body forward and heaves it inward against the ringwulst

of the lens. In great contrast to forms below and above them, the Sauropsida have the ciliary body in immediate contact with the lens so that direct pressure can be exerted thereon, causing its anterior surface to bulge and accommodating the eye for nearby objects. The ringwulst and the scleral ossicles are adaptive to this end—the former by extending the lens toward the ciliary body, the latter by supporting, against the intraocular pressure, a flattening or concavity of the eyeball wall whose effect is to place the ciliary body closer to the lens than it is in ichthyopsidan or mammalian eyes.

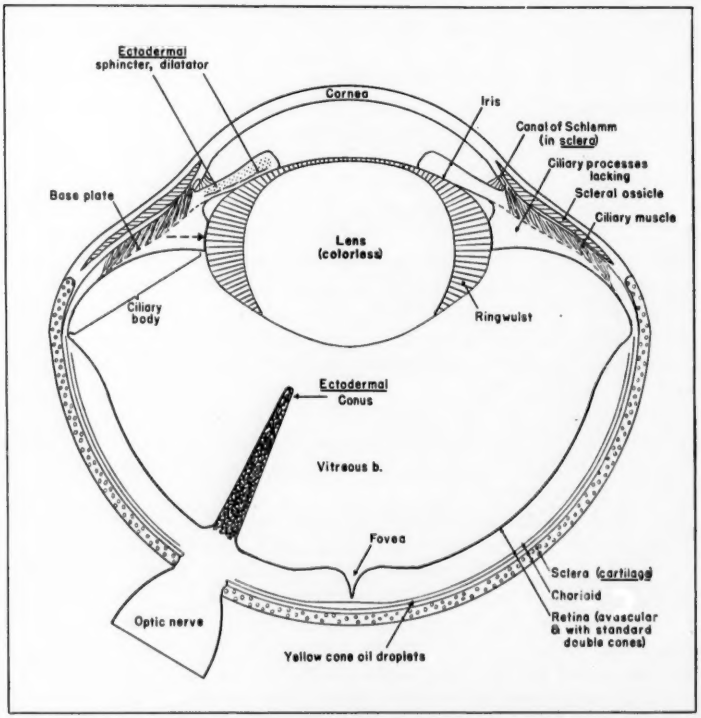

Fig. 1. Typical ocular schema of diurnal lizard. The dotted arrow shows the direction of the accommodatory force, which causes a bulging of the anterior face of the lens. The mass of the ciliary body bears directly upon the ringwulst of the lens—what appear to be ciliary processes are hence not such, but if they were, they would look the same in a section through two diametrically opposite ones. The drawing thus fairly represents the situation in Sauropsida generally, excepting the snakes.

There is a "transversalis" muscle which arises from the inner surface of the corneal margin, nasally, and passes through a midventral slit in the ciliary body (representing an unclosed portion of the embryonic fissure of the optic cup) to insert on the ventral periphery of the lens. Its action is to tilt the visual axis more nearly parallel to the body and thus aid the extraocular muscles in moments of binocular vision.

The muscles of the iris, though striated, are all ectodermal and arise, as in vertebrates generally, from the non-sensory anterior continuation of the retina which passes over the ciliary body and the posterior surface of the iris to end at the pupil margin. There is a powerful sphincter which is not confined to the immediate vicinity of the pupil. Many of its fibers are swung into radial directions to serve as the actual dilatator pupillae. An epithelioid dilatator, homologous with that of other vertebrates, never separated from the posterior (retinal) layers of the iris, may also be present.

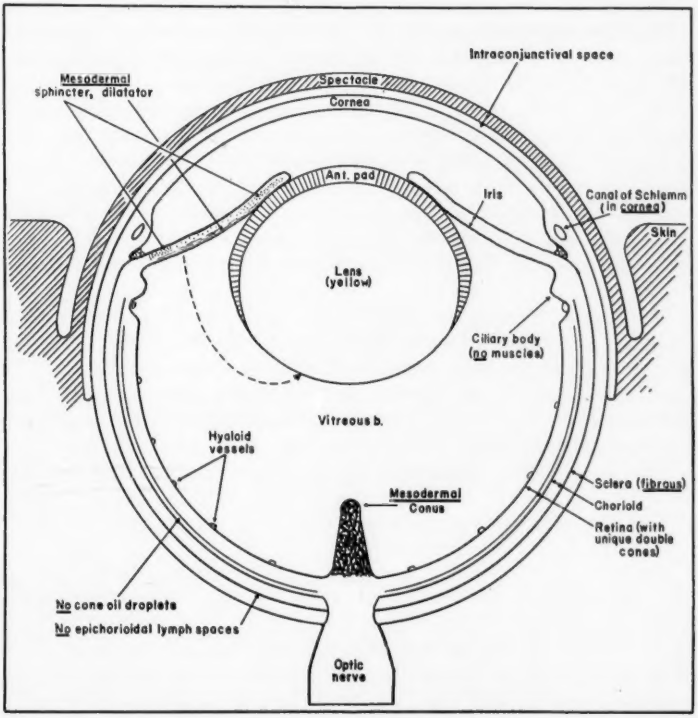

Fig. 2. Typical ocular schema of diurnal snake. The dotted arrow shows the direction of the accommodatory force, which is transmitted through the vitreous body and moves the lens forward without its shape being changed.

The canal of Schlemm, which constantly drains the continuously-produced aqueous humor, is amply connected with chorioidal veins, and also with conjunctival veins, but not with vessels of the iris.

The retina, except in the few nocturnal forms, has a fovea (see Walls, 1937) and contains no rods—the dim-light receptors—but only single and double cones, each with a yellow oil-droplet which serves as a visual-acuity-promoting color-filter (Walls, 1931, 1934a, Walls and Judd, 1933). The optic

nerve is unique in its possession of a purely neuroglial septal system, and from its head there projects a "conus papillaris." This deeply pigmented structure, circular or triradiate in cross section, is homologous with the much more elaborate "pecten" of the birds. It reaches through the vitreous humor toward the optical center of the lens, hence can cast no shadow upon the functional portions of the retina. It consists largely of small blood vessels in a pigmented matrix of neuroglial, therefore *ectodermal,* tissue. Its vessels are not generated from the hyaloid artery of the embryonic optic nerve, for this disappears before the conus is formed.

Turning now to the ophidian eye (Fig. 2) we find that not a single one of the above statements holds true for it. The eye is either spherical or (as in nocturnal forms with deep anterior chambers) has the optic axis a little greater than the equatorial diameter. The sclera and cornea are purely fibrous, there being neither a cartilaginous scleral cup nor scleral ossicles. The chorioid and sclera are firmly fused whereas in other vertebrates (including lizards) they are easily separable because of the epichorioidal lymph spaces. The ciliary body is narrow and very simple, consisting only of the tall-celled double epithelium which represents the blind forward continuation of the retina, and is entirely devoid of muscle. Both the protractor and the transversalis are gone from it, though only the latter has actually disappeared from the eye.

The stroma of the highly vascular iris contains a rich plexus of striated muscle fibers with sphinctral and radial orientations, the circular fibers being concentrated near the pupil margin and again at the root of the iris. This entire musculature is *mesodermal*—an unheard-of situation elsewhere in vertebrates—and has invaded the iris from the ciliary body, leaving the latter practically devoid of mesodermal tissue.

The iris is bulged far forward by the large lens, which is practically spherical as in fishes, for the cornea cannot do its fair share of focussing the image on the retina since it is optically eliminated by the flatter "spectacle" which covers the eye of every snake.

The lens lacks a ringwulst and this, together with the convexity of the ciliary region due to the absence of scleral ossicles, takes it quite out of contact with the ciliary body. There is usually an "anterior pad," however, which aids the lens in attaining its subspherical shape. The lens is firmer than in turtles, even in aquatic snakes which need a greater range of accommodation if they are to compensate for the loss of the spectacle's refracting surface when under water.[1]

The canal of Schlemm is only occasionally a continuous annulus and usually lies anterior to its customary location in other vertebrates. It has connections with iris vessels as well as with those of the chorioid and conjunctiva.

In the retina (Walls, 1934a) a number of visual-cell patterns occur. The Boidae have both rods and single cones. The Colubridae typically have only cones, and all of the duplex or pure-rod retinae of nocturnal colubrids and

[1] The refractive index of the tissue of the spectacle seems never to have been determined. It may prove, after all, to be much higher than that of the average cornea. Horn is known to have a very high index (=1.5473, tortoise-shell=1.5907; Valentin, 1879) compared with vertebrate corneae (1.3405—1.3805; water=1.330).

of higher families are easily derivable from the diurnal colubrid pure-cone pattern. No type of cone in any snake possesses an oil-droplet and the ophidian double cone is quite unique, not homologous with the double cones of any other vertebrates, and invented within the Colubridae.

There is a "pecten" in many snakes, but it is totally different from that of lizards and other Sauropsida. It is never so large, and even where it is largest in adults it is still larger in their embryos. This, together with its inter- and intra-specific variability, tells a story of degeneration. The ophidian structure is *mesodermal,* of connective tissue vascularized by the hyaloid circulation, from which vessels (lacking in lizards) also radiate along the interface of the retina and the vitreous. These develop embryologically as the conus papillaris regresses, as though to take its place in the nutritional pattern of the eyeball. Otherwise, the intraocular vascularization of the snake is vestigial as compared with other Sauropsida.

It has been pointed out elsewhere (Walls and Judd, 1933) that the absence of oil-droplets in snake cones, and the substitution for them of a yellow coloration of the lens in diurnal species, shows the snakes to have originated as a photophobic group. The yellow lens always appears in strongly diurnal forms whose ancestors were nocturnal and discarded oil-droplets (diurnal geckoes, diurnal sciurids, *Tupaia,* man; Walls and Judd, 1933; Walls, 1940).

The universality of the spectacle in snakes supports this conclusion. This protective device is formed largely from the lower lid (Schwartz-Karsten, 1933, Neher, 1935) and among lizards is possessed only by nocturnal, subterranean, and deserticolous forms (Walls, 1934b), the latter as often provided only with a transparent window in a lid of normal mobility. Only a minority of snakes fall into these ecological categories, yet all have the spectacle. This can only mean that the "original" snake had one or more of these habits, and persisted therein for a considerable time.

A few years ago the writer felt convinced that the snakes originated as a nocturnal offshoot of some lacertilian family (presumably of course the Varanidae), thoroughly-enough nocturnal to have developed the spectacle which most modern snakes no longer need (yet must perforce retain), and nocturnal for a long period of time—sufficiently long to permit not only of the decolorization of the ancestral lacertilian cone oil-droplets (as in nocturnal lizards such as *Xantusia* and *Heloderma*) but of the ultimate complete disappearance, as in geckoes, of the droplets themselves.

Upon more recent reflection over the entire contrast presented by the ocular schemata of lizards and snakes, the writer is now prepared to go further. The snake eye is literally a bundle of substitutes. The substitutions need never have been made at all if the snakes had had well-developed eyes at all times in their early history. The lacertilian eye, absolutely unchanged, could have served the first snakes perfectly well if they had differed in habits from most lizards only as much as does, say, *Ophisaurus*. If the pro-ophidians had been simply legless lizards of the *Ophisaurus* type, but nocturnal in habit, they would have needed at most to bleach their oil-droplets and to convert their lids into a spectacle as has *Pygopus*. In lizards which have a

spectacle, the latter has not in itself entailed any changes in the eye proper, beyond some histological simplification of the cornea.

Aside from the absence of oil-droplets and the presence of a spectacle, the many other differences between all snake eyes and most lizard eyes defy so simple an explanation as a presumptive mere nocturnality on the part of the first snakes. But all of the differences, including these two, are entirely consistent with the hypothesis that *the early snakes were subterranean and their eyes underwent wholesale degeneration into a condition fairly well represented by the modern Amphisbaenidae, from which they have recovered by a remarkable evolutionary "come-back."* It was during a long period of *Amphisbaena*-like existence that the ophidian type finally crystallized, later to blossom into a "respectable" group in which wholesale substitutions were necessitated in order to restore the eye to decent usefulness and support an active, above-ground, and diurnal habit. We can imagine the retrogression and recrudescence of the eye, accompanying those processes in the whole animal, to have involved losses and subsequent substitutive inventions about as follows:

As the legless lacertilian pro-ophidian became small-bodied and secretive, it lost the fovea and the pigmentation of the oil-droplets. The eyeball shrank and lost its ellipticity, and the transversalis muscle atrophied. Going on into further secretiveness and nocturnality, lid mobility disappeared and the spectacle became a permanent feature. The pupil had probably now become vertical to protect an extra-sensitive retina, and as time went on the double cones and the decolorized oil-droplets were done away with. The simplification of the retina and the loss of any high ratio of visual cells to optic nerve fibers led to a relative and absolute diminution of the latter and to a loss of the septal system of the optic nerve.

The eye becoming steadily smaller, the conus papillaris was allowed to dwindle and, along with other features of the intraocular circulatory pattern, was eventually dispensed with. As the underground habit was adopted and became fixed, the pupil probably at first rounded up again (since the animal was no longer ever intentionally exposing itself to bright light), then lost all mobility as the ectodermal iris muscles disappeared entirely. Accommodation being by now a useless refinement, the ringwulst vanished and the lens became firmer and lost all contact with the ciliary body. The tiny eye no longer needed such support as given by a scleral cartilage, and as the sclera became fibrous the scleral ossicles went the way of the ringwulst with which they had once been functionally associated. Freed of such local resistances to the intraocular pressure the eye rounded out to the perfect ball which it has since remained.

Though the ciliary body had become narrow, it still tenaciously retained some muscle fibers—much as these had hung on, uselessly, through the amphibia to be put to work once more by the reptiles. Degeneration in the wall of the eyeball expressed itself in a fusion of the chorioid and sclera, in reality a rudimentation or halting at a stage of embryonic differentiation prior to the customary formation of epichorioidal lymph spaces. With no intraocular movements now occurring, and the eye by now very small, the canal of

Schlemm vanished or at least became discontinuous. The eye had touched bottom.

All this took time—how much time, no one could say; nor can it be guessed how long the ophidian eye remained in this sad condition. However, the ophidian type at last bestirred itself into a rejuvenation which brought it once more above-ground, and set about repairing the eye as best it could. The snakes entered upon a period of above-ground nocturnality which still persists in the lowest living families. The enlarging eye came to require an improved circulation, and an entirely new conus papillaris was manufactured from the connective tissue of the hyaloid vessels. These were eventually to give rise to a network supplying the retino-vitreal interface, eventually permitting the phylogenetically temporary mesodermal conus to degenerate more or less completely in different sub-groups.

A brand-new musculature for the operation of the (at first) vertical pupil was commandeered from the ciliary body, enough of the fibers remaining at the periphery of the iris to serve as the unique ophidian accommodatory mechanism, wherein the backward pressure of the tensed iris upon the vitreous is communicated by the latter to the back of the lens, pushing the lens bodily forward without need of a change of its shape—a return to the essentials of elasmobranch and amphibian accommodation though without so direct a muscular action upon the lens.

The pull of the iris upon the sclero-corneal junction during accommodative effort indents this portion of the globe wall, tending to raise the intraocular pressure. This, together with the reappearance of intraocular shiftings of parts, and the growth of the eyeball, called for an improvement of the reduced mechanism of aqueous-drainage and production. The epithelium of the narrowed ciliary body became folded, both annularly and by the production of something like ciliary processes, to increase its secretory surface. A new canal of Schlemm appeared, in a new (corneal) location; or, if the ophidian canal *is* homologous with the lacertilian one, it at least gained new vascular connections to compensate for its discontinuity.

As diurnality became the standard habit upon the differentiation of the Colubridae, the lens developed the anterior pad (lacking in, e.g., *Eryx*) and the yellow pigment, lentiflavin (Walls, 1940), to replace the lost oil-droplets. A new and unique type of double cone was evolved, and as the optic nerve gained relatively and absolutely in number of fibers, a new septation system, quite unlike the abandoned lacertilian one, was devised.

All of the important defects which had developed during the snakes' long sojourn in quasi-oblivion had now been remedied. Even a fovea was produced where needed, as in *Dryophis* (Walls, 1932), though owing partly to the lack of a transversalis muscle it was of necessity placed in the extreme caudad periphery of the retina and has demanded a deformation of the pupil into a horizontal keyhole to afford it a forward line of sight. The diurnal snakes did not need the spectacle with which they found themselves provided, but it did not handicap them; and it became a welcome equipment to the many colubrids and higher snakes which eventually reverted to nocturnality.

This elaborate surmise as to the reason for the peculiarly aloof position of the ophidian eye may or may not receive support from those whose attack

upon the problem of ophidian origin is based upon anatomical features other than the eye. The simplification of the skull (compare the Amphisbaenidae!) and the disappearance of the ear, however, are old puzzles which seem to lose their mystery when considered as consequences of a former subterranean existence of considerable duration. If it be considered improbable that a very degenerate eye could ever recover to any extent, the remarkable case of *Proteus* might well be called to mind. The adult of this form normally has as degenerate an eye as any outside of the blind fishes, but develops as good an eye as that of *Necturus* when the larva is raised in the light (Kammerer, 1912, 1913).

The writer feels satisfied that his hypothesis is at least consistent with itself, and offers it as perhaps the first explanation of why, so to say, the various legless lizards are not snakes: they have elided, in their own origins, that painful period of near-extinction which the snakes experienced and which they have gloriously survived—though some legless lizards of the present time seem to be experimenting with such a future, and may conceivably emerge as convergent "snakes" an eon or two from now.

Literature Cited

Franz, V.
1934 Vergleichende Anatomie des Wirbeltierauges. In: Bolk-Göppert-Kallius-Lubosch, Handbuch der vergleichende Anatomie der Wirbeltiere, Bd. 2: 989–1292. Berlin and Vienna: Urban and Schwarzenburg.

Kammerer, P.
1912 Experimente über Fortpflanzung, Augen Farbe und Körperreduction bei Proteus anguineus Laur. (Zugleich: Vererbung erzwungener Farbveränderungen. III.), *Arch. f. Entwicklungsmech.*, 33: 349–461.
1913 Nachweis normaler Funktion beim herangewachsenen Lichtauge des Proteus. *Arch. f. d. ges. Physiol.*, 153: 430–440.

Neher, E. M.
1935 The origin of the Brille in *Crotalus confluentus lutosus* (Great Basin Rattlesnake). *Trans. Amer. Ophthalmol. Soc.*, 71st Annual Meeting, Hot Springs, Va.

Schwarz-Karsten, H.
1933 Über Entwicklung und Bau der Brille der Ophidiern und Lacertiliern und die Anatomie ihrer Tränenwege. *Morph. Jahrb.*, 72: 499–540.

Valentin, G.
1879 Ein Beitrag zur Kenntnis der Brechungsverhältnisse der Thiergewebe. *Arch. f. d. ges. Physiol.*, 19: 78–105.
Fortgesetzte Untersuchungen über die Brechungsverhältnisse der Thiergewebe. *Ibid.*, 20: 283–314.

Walls, G. L.
1931 The occurrence of colored lenses in the eyes of snakes and squirrels, and their probable significance. Copeia, 1931: 125–127.
1932 Pupil shapes in reptilian eyes. *Bull. Antivenin Inst. Amer.*, 5: 68–70.
1934a The reptilian retina. I. A new concept of visual-cell evolution. *Amer. Jour. Ophthalmol.*, 17: 892–915.
1934b The significance of the reptilian "spectacle." *Ibid*, 17: 1045–1047.
1937 Significance of the foveal depression. *Arch. f. Ophthalmol.*, 18: 912–919.
1940 The pigment of the vertebrate lens. *Science*, 91: 172.

Walls, G. L., and H. D. Judd
1933 The intra-ocular colour-filters of vertebrates. *Brit. Jour. Ophthalmol.*, 17: 641–675 and 705–725.

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Correct Terminology in Salamander Myology
II. Transverse Ventral Throat Musculature

By Jean Piatt

THE first part of this study was concerned with the correct terminology of the intrinsic gill musculature of the Caudata. The second part considers the proper terminology of the ventral transverse throat musculature. As in the first part, the literature cited is only a fraction of the papers consulted.

Transverse Ventral Throat Musculature

The larvae of all salamanders have four superficial transverse ventral throat muscles. In the adults there may be either three or four, depending on the species. The prevailing terms—and those which are the only logical ones from the standpoint of comparative anatomy and embryology—are: intermandibularis anterior, intermandibularis posterior, interhyoideus, interhyoideus posterior, inter-ossaquadrata, quadrato-pectoralis, subhyoideus, and gularis. It remains only to demonstrate the proper allocation of these terms among the various urodele genera.

In the larvae of all salamanders the most anterior, small, and occasionally indefinite muscle without a median raphe is the intermandibularis anterior. In the Proteidae, Necturidae, Amphiumidae, Cryptobranchidae, and Sirenidae this muscle persists throughout life. There may be occasional exceptions to this, but they are individual aberrancies and not differences between species. In the remaining families, Hynobiidae, Ambystomidae, Salamandridae, and Plethodontidae, the intermandibularis anterior disappears completely at metamorphosis. In these last four families, then, the most anterior muscle in the metamorphosed adult is the intermandibularis posterior. The fact that this latter muscle is very often subdivided into a number of separate slips has caused some confusion, and the entire muscle has very often been erroneously called the intermandibularis anterior by some writers, including the author (Piatt, 1935). According to Eaton (1936: 49) the account given by Hoffmann (1873–1878: 95) is the best source of information concerning the presence of the intermandibularis anterior in urodeles. Hoffmann's brief account is inadequate and definitely wrong. A more detailed and very accurate paper on this subject is the one by Luther (1914).

It has been shown (Edgeworth, 1911, 1935; Piatt, 1938) that the transverse throat muscles posterior to the intermandibularis posterior arise in the early salamander embryo as a single mass of mesoderm derived from the fusion of the ventral portions of the hyoid arches. Later the mass splits into an anterior interhyoideus and a posterior interhyoideus posterior. Both these muscles are maintained throughtout life in all salamanders, but with certain definite changes in different genera. Those species in which metamorphosis occurs normally and in which the interhyoideus and interhyoideus posterior remain unaltered are the Cryptobranchidae, Amphiumidae, and Ambystomidae. In these families the larval interhyoideus and interhyoideus posterior are carried over into the adult animal unchanged, save for a slight shifting of

origin and insertion. The majority of the larval musculature suffers comparable changes at metamorphosis and I can see no reason for changing the name of the interhyoideus posterior, for instance, to the quadrato-pectoralis in the adults of these families. Furthermore, since the interhyoideus posterior bears the identical relationship to the interhyoideus that the intermandibularis posterior does to the intermandibularis anterior, the term interhyoideus posterior should be retained for that muscle in adults of the Cryptobranchidae, Amphiumidae, and Ambystomidae.

In the adults of all genera of the Plethodontidae a new muscle arises at metamorphosis. This muscle was first described by Smith (1920), and called by her the gularis. It has been shown that the gularis muscle arises at metamorphosis from the interhyoideus posterior (Piatt, 1935). The interhyoideus posterior itself at metamorphosis does one of three things, depending on the genus. In the genera *Stereochilus, Typhlotriton, Gyrinophilus, Pseudotriton, Eurycea, Manculus, Plethodon, Ensatina, Hemidactylium, Batrachoseps, Hydromantes,* and *Oedipus* it disappears almost completely and the gularis takes its place. In the genera *Desmognathus* and *Leurognathus* it persists as a well developed muscle along with its derivative, the gularis, the latter muscle lying external to it. In *Aneides* the interhyoideus posterior persists as in *Desmognathus* and *Leurognathus* along with the gularis but with this difference, that the gularis lies internal instead of external to it.

In the last three genera the interhyoideus posterior, by virtue of the fact that it has given part of itself in the formation of a new muscle (gularis), is not identical with its counterpart in the larva and should be known as the quadrato-pectoralis (Drüner) to distinguish it from the larval muscle. In the other genera of the Plethodontidae, of course, it simply ceases to exist, and the gularis is the most posterior ventral throat muscle.

Eaton (1937: 324) suggests that the most posterior muscle of the transverse superficial throat series be called the gularis in all urodeles and that the additional integumentary slip of the Plethodontidae does not merit the name gularis as a separate term. The fact that this intergumentary muscle is peculiar to the entire Plethodontidae and the fact that it occurs in three distinct relationships within the family is sufficient reason, I think, for considering it a distinct muscle. Its ontogenetic origin from the interhyoideus posterior is beside the point in this connection. It would be just as correct to argue that since the intermandibularis anterior separates off from the intermandibularis posterior, these two muscles be known by only one name.

Drüner (1901) has described a muscle, which he calls the geniohyoideus lateralis, in adult *Salamandra* and *Triturus;* and another muscle in *Hynobius* (1904) which he calls the subhyoideus. This latter muscle, which arises at transformation or shortly before, separates off from larval interhyoideus, anteriorly. Drüner does not describe either of these muscles in *Ambystoma.* Both, in the forms just mentioned, have their insertion on the posterior part of the ceratohyal and meet in a median raphe on the throat. The subhyoideus, in addition, has a lateral head which arises on the lower jaw, lateral to the geniohyoideus.

Smith (1920) describes a geniohyoideus lateralis in adult *Eurycea,* which arises at transformation or just preceding it. She states that this muscle arises

ontogenetically as a lateral slip of the geniohyoideus, the latter thus becoming the geniohyoideus medialis. The geniohyoideus lateralis of Smith has its origin on the lower jaw, just laterad of the geniohyoideus (medialis), and inserts along the anterior border of the ceratohyal. A few of these muscle fibers continue posteriorly and are attached to the floor of the pharynx. Smith does not give the innervation of this muscle.

Edgeworth (1935) tacitly assumes that the muscle described by Drüner as the geniohyoideus lateralis in *Salamandra* and *Triturus* and the muscle of the same name described by Smith in *Eurycea* are one and the same. On page 195 he says, "In adult stages of *Salamandra, Triton* (= *Triturus*), and *Spelerpes* (= *Eurycea*) there is also a geniohyoideus lateralis, which is proliferated from the geniohyoideus."

Francis (1934) calls this muscle in *Salamandra* the subhyoideus. He states further that it is innervated by branches from the ramus jugularis of the seventh nerve.

In adults of *Ambystoma maculatum, A. texanum, A. opacum, A. tigrinum, A. talpoideum,* and *A. jeffersonianum* there is no geniohyoideus lateralis, either as described by Drüner in *Salamandra* and *Triturus* or by Smith in *Eurycea*. The muscle which corresponds to the geniohyoideus lateralis of Smith, however, is the lateral slip of the genioglossus. In *Ambystoma* this muscle has no actual insertion on the ceratohyal; otherwise it would agree perfectly with the description of the geniohyoideus lateralis in *Eurycea*. It arises as a lateral splitting of the genioglossus of the larva, which in turn is merely a separate slip of the geniohyoideus. From a purely comparative embryological and anatomical standpoint there is no doubt that this muscle in *Ambystoma* is homologous to the geniohyoideus lateralis of the Plethodontidae (Smith, 1920; Piatt, 1935).

In *Salamandra salamandra, Triturus pyrrhogaster, T. torosus, T. viridescens,* and *Pleurodeles waltli* there is a muscle which corresponds exactly with what Drüner has called the geniohyoideus lateralis of the Salamandridae. In *Hynobius naevius* the muscle is similar in its relation to the geniohyoideus lateralis of the Salamandridae, with the exception that there is an anterior slip attaching to the lower jaw just as Drüner described it in this species. This muscle in all these forms is innervated entirely by the ramus jugularis of the seventh. I have not traced its embryological origin, but from its innervation and relation with the interhyoideus of the larva and adult it is unquestionably a derivative of this latter muscle.

I have determined the innervation of the geniohyoideus lateralis in every genus of the Plethodontidae, several by serial sections, and in all cases the nerve supplying this muscle is the hypoglossus. The muscle in this family is innervated by branches which bear approximately the same relationship to the hypoglossal nerve as do those innervating the genioglossus lateralis in the Ambystomidae.

In view of the facts just presented I consider the following interpretation valid in regard to the terminology which should be employed in the case of these muscles. The muscle in the Salamandridae and Hynobiidae, which was discussed above, is homologous in these two families (arises from the interhyoideus and consequently from the mesoderm of the hyoid arch) and should

be called the *subhyoideus*. The term subhyoideus is more appropriate since this muscle has no relation whatsoever with the musculature of the hypoglossal nerve, either ontogenetically or anatomically. The muscle described by Smith as the *geniohyoideus lateralis* should be retained only for

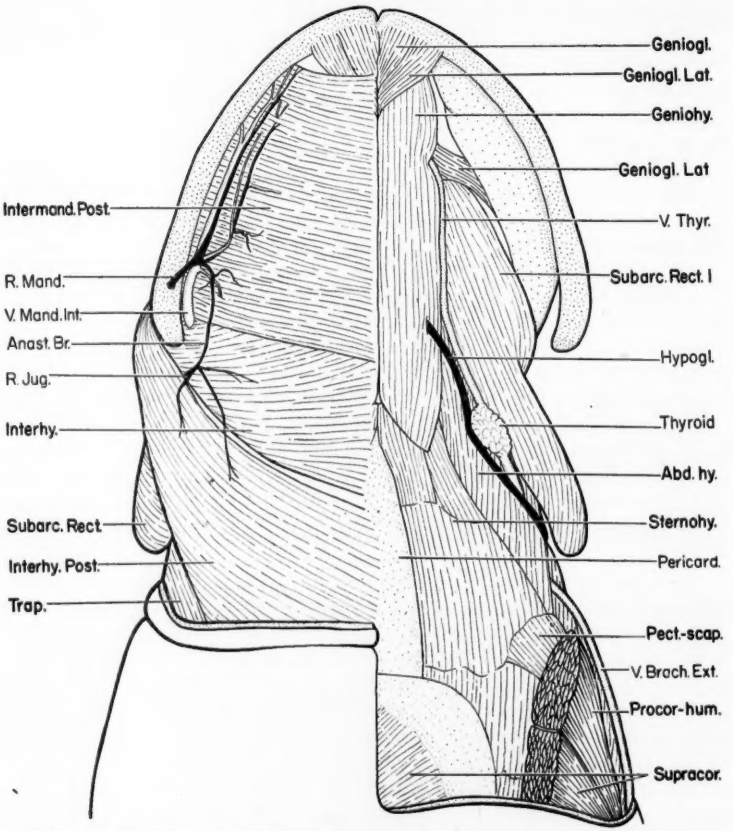

Fig. 1. Dissection of full grown larva of *Ambystoma maculatum* to show superficial musculature of head, ventral view. X4.

that muscle as it occurs in the Plethodontidae, since it arises from the geniohyoideus and consequently from the second trunk myotome. The genioglossus lateralis of the Ambystomidae is the homologue of the geniohyoideus lateralis of the Plethodontidae, but since its definitive relations are slightly different from that muscle in the latter family, there is no necessity for incorporating the name geniohyoideus lateralis in the nomenclature of the Ambystomidae. Since the interhyoideus of the salamandrid larva forms both the subhyoideus and a posterior portion in the adult, this posterior portion

is not the same as the larval interhyoideus and Drüner's term *inter-ossa-quadrata* might be used for it. In the Cryptobranchidae, Amphiumidae, and Ambystomidae the larval interhyoideus forms no subhyoideus in the adult, hence the name *interhyoideus* for the adult muscle is legitimate.

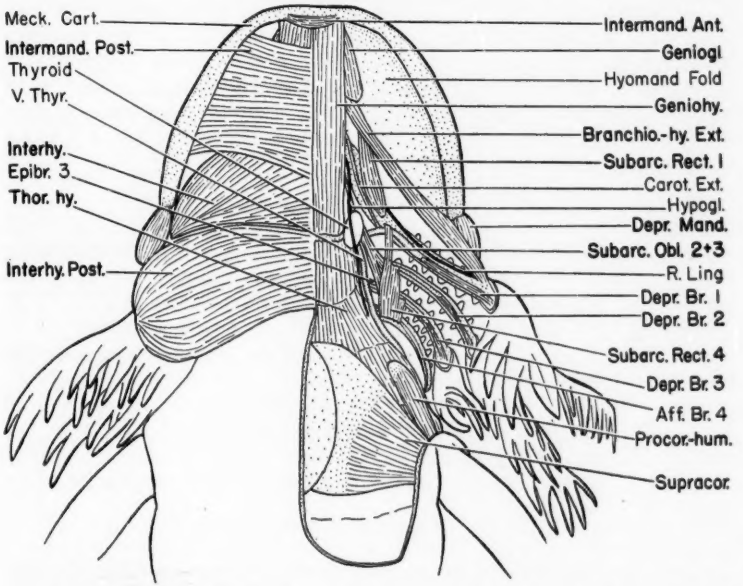

Fig. 2. Dissection of full grown adult of *Ambystoma maculatum* to show superficial head musculature, ventral view. X2.

Abd. hy., M. abdominohyoideus
Aff. Br. 4, afferent branchial artery 4
Anast. Br., anastomotic branch
Carot. Ext., external carotid artery
Branchio-hy. Ext., M. branchio-hyoideus externus
Depr. Br. 3, M. depressor branchii 3
Depr. Mand., M. depressor mandibulae
Epibr. 3, epibranchial cartilage 3
Geniogl., M. genioglossus
Geniogl. Lat., M. genioglossus lateralis
Geniogl. Med., M. genioglossus medialis
Geniohy., M. geniohyoideus
Hyomand. Fold, hyomandibular fold
Hypogl., N. hypoglossus
Interhy., M. interhyoideus
Interhy. Post., M. interhyoideus posterior
Intermand. Ant., M. intermandibularis anterior
Intermand. Post., M. intermandibularis posterior
Meck. Cart., Meckel's cartilage
Pericard., pericardium
Procor.-hum., M. procoraco-humeralis
Pect.-scap., M. pectori-scapularis
R. Jug., N. ramus jugularis VII
R. Ling., N. ramus lingualis IX
R. Mand., N. ramus mandibularis V
Subarc. Obl. 2+3, Mm. subarcuales obliqui 2 and 3
Subarc. Rect. 1, 4, Mm. subarcuales recti 1 and 4
Sternohy., M. sternohyoideus
Supracor., M. supracoracoideus
Thor. hy., M. thoracicohyoideus
Thyroid, thyroid gland
Trap., M. trapezius
V. Brach. Ext., external branchial vein
V. Mand. Int., internal mandibular vein
V. Thyr., thyroid vein

Summary

1. All larval and perennibranch urodeles have four superficial transverse ventral throat muscles. These are from anterior to posterior: *intermandibularis anterior, intermandibularis posterior, interhyoideus,* and *interhyoideus posterior.* The intermandibularis anterior disappears in metamorphosed adults of the Hynobiidae, Ambystomidae, Salamandridae, and Plethodontidae, leaving the intermandibularis posterior as the most anterior muscle.

2. In the adults of the Hynobiidae and Salamandridae the interhyoideus becomes two muscles. The most anterior of these should be known as the *subhyoideus*, the posterior portion as the *inter-ossa-quadrata*. In the rest of the families the single larval unit, interhyoideus, remains thus and retains the same name.

3. In metamorphosed Plethodontidae the interhyoideus posterior becomes either two muscles or, having given rise to an integumentary muscle, disappears entirely. The term *gularis* should be restricted to the integumentary derivative of the interhyoideus posterior; when the remainder of the interhyoideus posterior is present also, it should be called the *quadrato-pectoralis*. In all other families the most posterior muscle should retain its larval name, interhyoideus posterior.

Literature Cited

Drüner, L.
1901 Studien zur Anatomie der Zungenbein-, Kiemenbogen-, und Kehlkopfmuskeln der Urodelen. I. *Zool. Jahrb.* (*Anat.*), 15: 435-622.
1904 Studien zur Anatomie der Zungenbein-, Kiemenbogen-, und Kehlkopfmuskulatur der Urodelen. II. *Ibid.*, 19: 361-690.

Eaton, T. H., Jr.
1936 The myology of salamanders with particular reference to *Dicamptodon ensatus* (Eschscholtz). I. Muscles of the head. *Jour. Morph.*, 60: 31-75.
1937 The gularis muscle in Urodela. *Ibid.*, 60: 317-324.

Edgeworth, F. H.
1911 On the morphology of the cranial muscle in some vertebrates. *Quart. Jour. Micr. Sci.*, 56: 167-316.
1935 The cranial muscles of vertebrates. Cambridge: viii + 493.

Francis, E. T. B.
1934 The anatomy of the salamander. Oxford: xxxi + 381.

Hoffmann, C. K.
1873-1878 Amphibien. *In* Bronn, Klassen und Ordnungen des Thierreichs., Bd. 6(2): 1-726.

Luther, A.
1914 Über die vom N. trigeminus versorgte Muskulatur der Amphibien. *Helsingf., Acta soc. Sci. Fenn.*, 44: 1-151.

Piatt, Jean
1935 A comparative study of the hyobranchial apparatus and throat musculature in the Plethodontidae. *Jour. Morph.*, 57: 213-251.
1938 Morphogenesis of the cranial muscles of *Amblystoma punctatum*. *Ibid.*, 63: 531-587.
1939 Correct terminology in salamander myology. I. Intrinsic gill musculature. Copeia, 1939: 220-24, 2 figs.

Smith, Louise
1920 The hyobranchial apparatus of *Spelerpes bislineatus*. *Ibid.*, 33: 527-550.

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Notes from a Herpetological Diary, II

By L. M. KLAUBER

ANOTHER EXTENSION TO THE RANGE OF *Xantusia arizonae*.—On May 28, 1939, Charles Shaw succeeded in securing a specimen of this form at Valentine, Mohave County, Arizona, thus extending the range some 80 miles to the northwest. *X. arizonae* now has a total range, diagonally across central Arizona, of nearly 200 miles (see COPEIA, 1938: 193).

On a trip last year, past Valentine and Hackberry, some likely looking rocks had induced the resolve to return for a *Xantusia* hunt at the earliest opportunity, and the new record is the result. The rocks, however, were found too hard to flake easily and therefore our efforts produced only one specimen. It is my opinion that *X. arizonae* will eventually be found to have a considerably greater range than is now known, since suitable rocky areas are widespread through Arizona. However, only where the boulders exfoliate in weathering is capture simplified; elsewhere the lizards can seek diurnal refuge in crevices from which they cannot be extricated, or even their presence demonstrated.

An interesting feature of the new locality is that it carries the range of *X. arizonae* to within 30 miles of the known range of *X. vigilis*. No doubt they will eventually be found to overlap, occupying their respective niches of rock crevices and yuccas, just as *X. henshawi* and *X. vigilis* do in the desert foothills of southern California.

NOTES ON THE GENUS *Anniella*.—The status of the black legless lizard *Anniella nigra* Fischer, 1885, has been in doubt because of lack of live or well-preserved material from intermediate areas between its habitat in the Monterey Peninsula and the range of *Anniella pulchra* Gray, 1852, elsewhere in central and southern California. Cope, in 1900 (Rept. U.S.N.M. for 1898: 675), noting that the two forms differ only in color, considered *nigra* a subspecies of *pulchra*. Grinnell and Camp (Univ. Cal. Pubs. Zool., 17 (10), 1917: 170) took the same position, since specimens from Morro Bay, San Luis Obispo County, appeared to be intermediate in color. However, these specimens were in poor condition and of unstated age; and it has long been known that the juveniles of the two forms are more alike than the adults. I subsequently examined the same specimens and found that two were adults, but their condition was such that it was impossible to make any comparisons with well-preserved specimens of *nigra* and *pulchra*. Most recent authors have continued to consider the two forms valid species.

Through the courtesy of Waldo G. Abbott, of the Santa Barbara Museum of Natural History, I have lately received two adult specimens of the legless lizard taken at Pismo Beach, San Luis Obispo County. The dorsal colors of these are approximately halfway between *nigra* and *pulchra*. Mr. Abbott has likewise forwarded a specimen from near Santa Barbara. This is as light in color as those from farther south. Therefore the change in color takes place to the north of Santa Barbara; and, furthermore, it is evident only along the coast, for specimens from more northerly inland points such as San Ardo,

Monterey County, and Bear Valley, San Benito County, continue to exhibit the light colors of *pulchra*.

One of the Pismo Beach specimens in life was Deep Neutral Gray (Plate LIII of Ridgway, 1912), while the other was Deep Neutral Gray to Slate Gray. Miss Edna Fisher (COPEIA, 1934: 47) has reported live specimens of *nigra* from Pacific Grove, Monterey County, to be Clove Brown, Blackish Brown, or Fuscous Black. These are all *m* tones, while the Pismo specimens are *i* or *k*. A series of *pulchra* from Coronado Heights in San Diego County were examined alive and found to vary from *i* tones such as Buffy Brown and Tawny Olive through Wood Brown and Light Brownish-Drab to Plumbago Blue (an *f* tone). These tones match the general effect of the dorsal colors of *pulchra* rather than the exact colors; for under magnification the scales are seen to be mottled, rather than unicolor, and the scale edges are often dark, giving the effect of secondary longitudinal lines. The primary dark lines, of which there are usually three, one mid-dorsal and the others lateral, are prominent in *pulchra*, somewhat evident in the Pismo Beach intergrades, and rarely present in *nigra*. In *pulchra* the lateral lines separate the dorsal and ventral colors.

Below, the intergrades are Honey Yellow and Deep Colonial Buff. San Diego County adults from along the seacoast are Mustard Yellow, Wax Yellow, or Olive-Ocher. Miss Fisher has reported *nigra* as Wax Yellow, Lemon Yellow, Lemon Chrome, and Strontian Yellow.

I am of the opinion that the conclusions of Cope, and Grinnell and Camp, should be revived, and that the black legless lizard should be known as *Anniella pulchra nigra*, a subspecies of *A. p. pulchra*.

The head of *Anniella* is shaped like that of *Sonora occipitalis* and *Chilomeniscus cinctus*, the snout shovel-shaped and the lower jaw inset, although not as perfectly as in the snakes. In sand it burrows as rapidly as the snakes. The tongue is lavender; the mouth is opened when it is protruded. The eyes are black. The eyelids are seldom used but the eyes seem to be closed when the lizard is under sand. When held in the hand *Anniella* squirms violently, seeking any crevice into which the head may be thrust. Failing this, it twists laterally as do racers when similarly held. Sometimes it bites and the tiny teeth can be felt.

Messrs. Charles Shaw, Morris Bloomfield, and James Deuel found legless lizards quite common in the sand dunes above the high tide line at Coronado Heights, especially a few inches below the surface under sand verbena bushes. The dunes were networked with tracks. Raking the sand below bushes or debris often uncovers a specimen, which must be seized quickly to prevent its escape into the sand.

Additional specimens of *A. p. pulchra* have been found above ground since I previously commented on the rarity of dead specimens on the road as compared with *Leptotyphlops* (Bull. Zool. Soc. S. D., 14, 1939: 96). Charles Shaw found one which had just been run over at 7:23 P.M. in Sentenac Canyon, San Diego County. On May 18, 1939, I found one crawling on the pavement at 7:15 A.M. near Greenfield, Kern County, California. It had probably become stranded on this 4-lane highway. It was very active but was not making much progress on the smooth surface.

THE TYPE OF *Crotalus lugubris* JAN, 1859.—*Crotalus lugubris* Jan, 1859 (Revue et Magasin de Zoologie, (2)10: 153 + 156, or, as published in separate form: 28 + 31, plate E, 4th fig.) is composite. Four type specimens were listed in the original description, two from the Milan Museum, one from the Westphal collection, and one in the Paris Museum.

It has usually been assumed that the Milan and Paris individuals were specimens of *C. triseriatus* Wagler, 1830, while the Westphal specimen was conspecific with *C. polystictus* (Cope), 1865. The written description is brief and might fit several species, but suggests particularly *triseriatus, lepidus,* or *polystictus*. This is followed by scale counts of the four cotypes in tabular form.

Taking the Westphal specimen first, we know this to be *polystictus* since this specimen was later figured under the name *Crotalus lugubris multimaculata*[1] by Jan and Sordelli (Icon. Gén., 46: 1874, pl. III, fig. 3), and the figure is unmistakable. The name *C. l. multimaculata* was used by Jan as early as 1863 (Elen. Sist. degli Ofidi: 124), but still does not antedate Cope's *polystictus,* since the 1863 publication was a *nomen nudum* lacking description. Thus Cope's name stands, unless replaced by the earlier *lugubris*.

Returning to the Milan and Paris specimens of *lugubris* we know they were not *polystictus* because the scale rows are too low (23, whereas *polystictus* has 25 or 27) and the caudals are too high in two of the specimens. Jan's 1859 figure is not *polystictus* since it lacks the indented prenasal so characteristic of that form. The figure rather suggests *lepidus*, for the preocular is split vertically, and the prenasal is carried backward under the postnasal, as is characteristic of *lepidus*. However only one of the three could have been *lepidus,* this being the first Milan specimen; the other two have too high a caudal count, but do fit *triseriatus*.

With respect to this problem I have lately corresponded with Dr. G. Scortecci, of the Museo Civico de Storia Naturale of Milan. He advises me that Jan's two specimens still exist in the museum, one being in good condition. Of this he has kindly sent me an excellent photograph, and also scale counts which show it to be the second specimen listed by Jan. The photograph clearly depicts a specimen of *triseriatus triseriatus* (as we now know this form) characterized by a single dorsal series of irregular-edged blotches, thus differing from the northern subspecies *C. t. pricei,* which has a double row of dorsal spots. The low ventral scale count differentiates the specimen from *C. t. omiltemanus*. Although the locality of collection is given only as "Mexico," one may hazard the guess that it came from Veracruz, based on the low ventral scale count and the shape of the dorsal blotches. Specimens from near the City of Mexico have a greater number of ventrals and the blotches tend toward a circular or oval shape and are more likely to be even-edged, instead of square, with serrated edges, as in this specimen.

In order to set at rest any future confusion in the several names I designate this specimen, i.e., that described in the second column of Jan's table on p. 157 (p. 32 of the separate), which now is No. 1414 in the Milan Mu-

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[1] There is some discrepancy in the ventral scale count, given by Jan as 151, which is too low for *polystictus*.

seum, as the lectotype of *C. lugubris* Jan, 1859, thus placing *lugubris* definitely in the synonymy of *C. triseriatus* Wagler, 1830.

San Diego Natural History Society, San Diego, California.

A New Bromeliad Frog from Northwestern Michoacan

By Edward H. Taylor

In the collections made in Mexico during the summer of 1938, is a series of small frogs which were obtained from bromelias in low trees and cacti on the side of a low mountain near the southeastern end of Lake Chapala in northwestern Michoacán. It may be known as

Hyla ***smaragdina,*** sp. nov.

Type.—EHT–HMS No. 17534. Collected on mountain side rising from eastern end of Lake Chapala, 6 km. east of Cojumatlan, Michoacán, September, 1938, by E. H. Taylor.

Paratypes.—EHT–HMS Nos. 17526–17533; 17535–17554. Collected same place and date by Radclyffe Roberts and Edward H. Taylor.

Diagnosis.—A small bromeliad frog with vomerine teeth greatly reduced or wanting; no vocal sac, snout short; heel reaching to eye; interorbital space one and one-third width of eyelid; diameter of tympanun less than one-half the length of eye; two much-enlarged, flattened cream tubercles below anus, and a cream line above anus; a small but distinct axillary fold, with a more or less distinct skinfold along the sides of the body; chin and breast as well as abdomen strongly granulate; dark green above; yellowish or flesh white below.

Description of Type.—Head moderate in width, not wider than body; the interorbital width (3 mm.) about once and a third times width of eyelid (2.05 mm.), equal to length of eye (3 mm.); distance between nostrils slightly less than distance between eye and nostril; tip of snout rather truncate with nostrils very close to the anterior edge; a very slight rounded "nose" and a slight depression between nostrils; canthus distinct but somewhat rounding; tympanum small, distinct, its diameter (1.1 mm.) contained in length of eye more than two and two-thirds times; the upper edge partly covered by a narrow fold which runs from eye to some distance along the side above the arm.

Tongue very broad, broader than long, notched behind; vomerine teeth in two elongate transverse groups which are very low and indistinct; they lie almost wholly between the choanae which are rather large, rounding rather than oval; a conspicuous groove crosses the palate near the anterior edge of the choanae, marking termination of the mucuous glands.

Arm with a small axillary web which continues along side of body and groin as a slight fold; disks on outer finger conspicuously larger than the tympanum; web slight (as in figure); the distal subarticular tubercle is

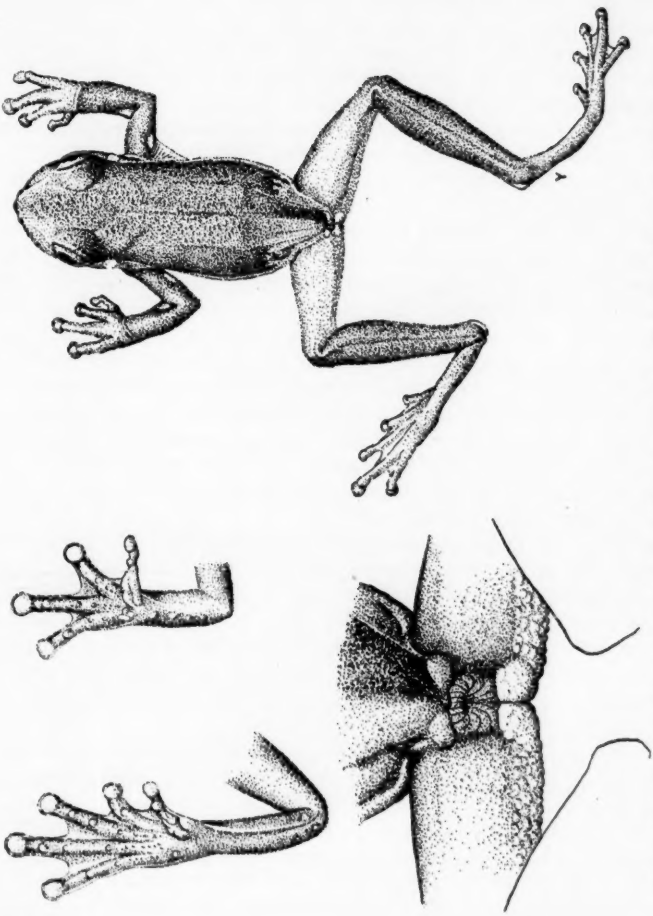

Fig. 1. Dorsal view of type of *Hyla smaragdina*, sp. nov., x 2. Hand and foot, x 3. Anal region, x 4.

single (rarely double); palmar tubercle in three or four parts; an indefinite row of tubercles on underside of forearm; legs rather short, the tibiotarsal articulation brought forward reaches to the posterior corner of eye; foot webbed as in figure; inner metatarsal tubercle oval, strongly salient; outer small, inconspicuous; numerous supernumerary tubercles; terminal disks smaller than those of outer fingers but equalling or exceeding slightly the tympanum; tibiotarsal fold sharply defined; skin above distinctly rugose save on snout which is smooth; chin, throat, breast, abdomen and the ventral surface of femur strongly granulate; there is some indication of granules on arm; a pair of swellings above anus, and two large somewhat irregular tubercles below anus (composed of a fusion of several granules); anal flap small, narrow region below anus with curving folds.

Measurements.—Snout to vent, 24 mm.; length of snout, 3 mm.; snout to arm, 8.2 mm.; width of head, 8.1 mm.; length of head, 7.8 mm.; arm, 15.5 mm.; leg, 35 mm.; tibia, 12 mm.; foot, 17 mm.

Color in Life.—Above dark green, the color slightly lighter on exposed surfaces of limbs and rump; below cream; the groin cream to yellow with a line which runs above the anus more or less connecting with the yellow of the opposite groin; anal region green; femur yellowish green above, more lightly pigmented than tibia, yellowish on posterior surface with slight pigmentation; two strongly-defined, unpigmented, yellowish cream spots cover the enlarged glandular tubercles below anus. Snout, lips and sides of head uniform green with no lighter or darker markings; some dark pigmentation around border of lower jaw; underside of foot and under surface of outer fingers with scattered pigment. A cream line across heel which may continue more or less on posterior surface of tibia.

Variation.—The general characters of color are strikingly uniform save for slight variation in the shade of green; measurements and body proportions are likewise very uniform. The shape of the tip of the snout varies a little, in some being more truncate than in type. In younger specimens the vomerine teeth are less distinct. I am unable to detect a vocal sac in males.

Remarks.—This large series lacks fully adult specimens. It is probable that the vomerine teeth attain greater development and that the snout may become more pointed.

All the specimens were obtained from bromelias growing in the cactus (*Opuntia*), small scattered trees and shrubs, or on rock ledges. They were very active. No eggs or tadpoles were found.

The habitat was visited in 1939 by Dr. Hobart M. Smith and myself exactly a year after the type series was obtained. We visited parts of the mountain not collected the previous year, and examined many plants in the immediate type locality. Only a single specimen was obtained.

The relationship of this form seems to be with a newly discovered *Hyla* (in press) from the high regions in the Cerro San Felipe near the city of Oaxaca. The latter apparently is not a bromeliad frog. It differs from that species in certain details of coloration, and in having a short anal flap instead of an elongated grooved flap. Vocal sacs are present in that species.

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Occurrence and Life History of the Northern Brook Lamprey, *Ichthyomyzon fossor*, in Indiana

By W. James Leach

IN THE course of my investigations during the last ten years on the endostyle and thyroid of the lampreys, considerable information has been gathered upon the natural history of *Ichthyomyzon fossor* in Indiana. Although many of these data are particularly related to the work on the thyroid, they appear to possess other points of interest and significance for the more general understanding of this species. This paper is intended to: (1) report for the first time the occurrence of *Ichthyomyzon fossor* for Indiana; (2) present a table of characters and point out the aberrant dentition shown by the specimens from that state; (3) describe the essential features of the life cycle with special reference to ammocoetes and transformation.

The observations to be reported here are based upon specimens taken from a half-mile stretch of the Tippecanoe River near Warsaw, Indiana. Collections and observations along this point of the river have been made every year since 1930. Living animals taken with the debris in which they burrow have been kept in aquaria at the University of Michigan, at the University of Pennsylvania and also at my home near Philadelphia, Pennsylvania. Probably for the first time, ammocoetes have matured and produced a second generation in captivity.

Acknowledgments

The author wishes particularly to express his thanks to Dr. Carl L. Hubbs, Museum of Zoology, University of Michigan, not only for making the identification, but for his thorough consideration of the manuscript and valuable suggestions. Recognition is also due Milton B. Trautman, Franz Theodore Stone Laboratory, Ohio State University, for making out the table of adult characters used in this report; and to Dr. J. Percy Moore, University of Pennsylvania, for his valuable help throughout.

Identification

The specific identification of lampreys in the ammocoete stage is extremely difficult, as is commonly known. In their *Revision of the Genus Ichthyomyzon,* Hubbs and Trautman (1937: 60) list three lots of ammocoetes from Indiana under *I. unicuspis*—though "possibly *I. fossor.*" Two of these lots were of my Tippecanoe River material and are now assumed to be *I. fossor;* they represent the first records of the species for the state, and also the only records of *I. fossor* in the Mississippi River system, except for one station in Wisconsin.

The present assumption that the two lots of ammocoetes taken from my collections are *I. fossor* is based on the circumstance that similar specimens from the same source have been carried through to the adult stage, and are therefore identifiable. The adults were reared from a collection of twelve full grown ammocoetes which was made June 15, 1937. These specimens were brought to Philadelphia where they were kept in aquaria. Of these, six transformed late in the following August and early September. Two males and one female were carried through until June 1, 1938. On that date they

were stripped of fertile eggs and sperm. One male and the female were sent to Dr. Hubbs for a check on the identification. These two specimens of *Ichthyomyzon fossor,* from the Tippecanoe River, at Warsaw, Indiana, now deposited in the Museum of Zoology (Cat. No. 105499), University of Michigan, represent the first adults of the species to be recorded for Indiana. The characters for the two animals are here given (Table 1), for comparison with the figures published by Hubbs and Trautman (1937: 70).

TABLE 1

COUNTS AND MEASUREMENTS OF TWO ADULTS OF *Ichthyomyzon fossor* REARED FROM AMMOCOETES COLLECTED IN TIPPECANOE RIVER, AT WARSAW, INDIANA

	Male	*Female*
Number of Myomeres	49	54
Supraoral cusps (median cusp small)	3	3
Infraoral cusps	7	9
Teeth in circumoral row	20	21
Teeth in anterior row	3	3
Teeth in lateral rows	4–4	4–4
Bicuspid circumorals	0	0
Development of disk teeth	Moderate (for species)	Moderate (for species)
Total length	103 mm.	108 mm.
MEASUREMENTS IN THOUSANDTHS OF TOTAL LENGTH		
Length of tail	289	287
Depth of body	73	58
Eye	14	12
Snout	54	42
Disk	50	42
Length over gill openings	106	105

In life, the adult retains the dark slate of the ammocoete over the dorsal surface. The ventral surface of the pharynx bears a silvery color which extends to a level just above the gill openings. Back of the pharynx, the ventral surface is gray, somewhat tinted with orange. The orange is particularly noticeable in the female where the eggs show through the body wall. The dorsal fin tends to be a light tan where it joins the body.

An aberration of the supraoral cusps occurs in the Tippecanoe River specimens. The supraorals are tricuspid rather than bicuspid as described for the species, a condition not reported heretofore for *I. fossor,* even as a variation, although it is known to occur, occasionally to usually, in the other species of the genus (Hubbs and Trautman, 1937: 28). Perhaps a form distinct from *I. fossor* is indicated. In other respects, the dentition is similar to the type as described and figured by Hubbs and Trautman (1937: 69, Pl. 2, Figs. C-D).

The data given in this report apparently concern but a single form. In a total of fourteen individuals representing adults of four different years, all showed the peculiar tricuspid supraoral.[1] Numerous myotome counts on the ammocoetes show consistency. No parasitic species of lampreys have been

[1] Dr. Hubbs has lately informed me that he has captured three adults about one mile above my collecting area on Tippecanoe River. These (one unspawned female and two males) were taken on May 14, 1939. Only the female of this collection exhibited the tricuspid supraoral. The males have the bicuspid supraoral usual to the species. Certain of the specimens I have previously examined had only the pattern of the dentition established. I have now examined four additional adults (two males and two females) and it appears that some animals which possess the tricuspid pattern may not develop the middle cusp. It is evident, therefore, that considerably more material and additional observations on development are required to determine the true character of the supraoral cusps.

reported from this section of the Tippecanoe River. The questioning of several fishermen and neighboring farmers has led to no positive information on the species. No one even reports having seen the adults. This indicates that the animals remain well hidden throughout their existence, do not exhibit conspicuous spawning runs, and are not parasitic on fishes.

The Ammocoete (Larval) Stage

The normal history of the ammocoete found in the Tippecanoe River appears generally similar to that of the species in Michigan streams, as given by Okkelberg (1922) and by Hubbs (1925). These investigators attempted to demonstrate the age groups of *I. unicolor* (= *fossor*) by a statistical treatment of length measurements. Their observations indicate that the ammocoete stage for this species lasts from five to seven years, but point out the difficulties of ascertaining the age status of the larger sizes. Schultz (1930), using *Lampetra* material in great numbers, attempted to show seasonal progression in growth rates. He gives a thorough discussion of the statistical methods used in ammocoete age determination, and also emphasizes the difficulties in interpreting the later extreme of size frequency curves.

Although my largest single collection of Tippecanoe River material numbers 127 individuals, it is evident from the literature on life cycles that I do not have collections of sufficient numbers and taken at suitable intervals to warrant the presentation of an age or growth curve. There are, however, certain factors in the biology of ammocoetes which seem significant in determining age groups and which have apparently been given inadequate consideration. One of these factors, which must be regarded as important, at least for the Tippecanoe River population, is a tendency toward the natural segregation of the different size groups. My empirical observations over a period of several years indicate that certain sand and silt deposits of the stream bed are predominantly inhabited by ammocoetes closely related in size and possibly of the same age.

Since there is a single spawning season, probably during the month of May in the Tippecanoe River, the smallest ammocoetes collected at that time are definitely one year old. These have often been found in fine washed sand in numbers up to fifty or more with little range in length, and naturally segregated. In September, the spawn of the breeding period of the previous May may be located, and the undisturbed yearlings of the previous observation may be correlated with the new hatch. By following this procedure and noting the most striking instances of larger size segregations over a period of years, I have constructed a general table of age groups. It must be stated that the specimens referred to below were arbitrarily selected as representative of natural groups found in the stream, and material was selected only where natural segregation was strikingly suggested.

Table 2

Size and Estimated Age of Ammocoetes Taken in Tippecanoe River on June 10, 1938

Number of Specimens	Range in Length	Average Length	Estimated Age
12	36– 42 mm.	38 mm.	1 year
10	54– 61 mm.	56 mm.	2 years
13	70– 78 mm.	73 mm.	3 years
22	102–112 mm.	105 mm.	4 years
16	122–135 mm.	125 mm.	5 years

In addition to the ammocoetes comprising the groups listed in Table 2, nineteen animals were taken from a single deposit which was rich in organic debris. These animals ranged from 118 to 145 mm. and comprised the entire ammocoete population of that particular deposit. Twelve of the group fell within the size limits of the presumed fifth year group but seven were from 138 to 145 mm. in length. As has been noted by previous investigators, these larger size individuals do not fall into compact groups as do the smaller sizes.

The chief difficulties encountered in using size frequencies to establish the later age group or groups appear in the following factors: (1) All ammocoetes upon reaching maximum size do not transform at the next transformation season. These non-transforming individuals of maximum length have not been kept under careful observation in sufficient numbers to determine when they do transform. (2) A reduction in length probably always occurs before the ammocoete begins transformation. This has not been definitely correlated with a probable non-feeding period or with the early transformation changes. (3) The seasonal growth rate has not been established (especially for the larger ammocoetes), and no correlations between length and weight have been considered. It further appears that the tendency toward a natural segregation of distinct size groups, together with an apparent selectivity of habitat, may seriously affect the validity of such interpretations of size-frequency data as have been made. Unless suitable collections are made from all areas where specimens are found, the distributions may be decidedly unbalanced so that undue significance may be attached to minor peaks in the size-frequency curves.

It is evident that a marked natural segregation of size groups does not always occur, as it certainly does at the collecting station on the Tippecanoe River. From my experience in digging ammocoetes in numerous streams in Michigan, Pennsylvania, and New York, it appears that the constancy of stream flow and variations in the quality of sand and silt determine, to a large measure, the type of size distributions. In this connection, it should be pointed out that my collecting station on the Tippecanoe River is but a few miles from Tippecanoe Lake, of which the river is the outlet. Consequently, the flow is relatively constant at that point, and there is a minimum of shift in the deposits of the stream bed. In streams more subject to floods and a greater mixing of the sediments, the natural segregation of ammocoete size groups is less striking. It appears probable that the ammocoetes move from place to place only when forced to do so either by the shifting of the stream bed or because of food shortage.

Before attempting to discuss the probable duration of the ammocoete stage for the Tippecanoe River form of *I. fossor*, the related data on the transformation process will be presented.

Transformation Season and Size of Ammocoetes

Under natural stream conditions in the Tippecanoe River, the earliest date for the beginning of transformation appears to be about August 20, and the latest date for the onset, about September 15. Ammocoetes first showing external indications of transformation vary from about 120 to 150 mm. in length. These measurements are of larvae collected just at the onset of

transformation or immediately prior to this period. Upon a basis of several more general observations, the specific results of a 1938 collection appears typical.

In a collection taken on *August 20, 1938,* consisting of thirty-two large ammocoetes (within the size range of transformation), only two showed external signs of transformation. These measured (1) 130 mm. and (2) 138 mm. respectively. The entire collection was taken then to Philadelphia, and the following observations recorded:

August 25.—Three more showed transformation characters: (3) 122 mm., (4) 132 mm. and (5) 135 mm.

August 28.—One additional: (6) 120 mm.

September 3.—One additional: (7) 125 mm.

September 5.—One additional: (8) 148 mm. (This is the largest transforming individual of this species the writer has seen.)

September 11.—Two others were transforming: (9) 130 mm., and (10) 135 mm. These last two were suspected of being in early transformation on September 8.

Observations were made daily and animals showing definite indications of transformation were immediately segregated. Two individuals were incorrectly judged to be transforming. These, of course, do not show in the results, but indicate the difficulty of separating the lampreys in the earliest stage of metamorphosis.

The average length of this group of ten individuals at the onset of transformation was 131 mm. That of the ten largest of the remaining twenty-two non-transforming specimens was 135 mm. This suggests that all of the ammocoetes may live for at least an entire year in the full grown condition and that a general reduction in length may even occur during this period. It is interesting to note that the largest ammocoete of the original thirty-two specimens measured 152 mm. and did not transform. The 152 mm. specimen is the largest on my record of more than 100 measured within the range of transformation size.

The actual data, based upon the 32 individuals of the 1938 collections suggest that only about one-third of the ammocoetes within the transformation size range at the onset of the transformation season do transform at that season. It is further indicated that a number of ammocoetes are found immediately following the onset of the season which are larger than the transforming individuals. The number of these large non-transforming specimens appears approximately equal to the number of transforming individuals. In other words, for each transforming animal found at the onset of transformation a somewhat longer non-transforming ammocoete may be found. On three separate occasions my collections included some ammocoetes which were of greater length than the longest transforming individual.

A reduction in the length of ammocoetes during transformation appears definite. The possibility that a period of negative growth occurs before the onset of metamorphosis, however, has apparently received no previous attention. The fact that ammocoetes are consistently present which are longer than the maximum length of transforming individuals indicates the existence of a rest period. These large non-transforming ammocoetes have an entire

year to pass before the next transformation season, and it is further suggested that a phase of negative growth occurs during the rest period. That such a rest period is usual is indicated by the relatively large number of the large non-transforming animals found immediately following the regular transformation season. Professor Gage (1927 : 176- 177) has reported a similar circumstance for the lake lamprey. He suggests that the full grown condition of these ammocoetes extends throughout an entire year. No comparable measurements were given by Gage for the lake lamprey.

The suggested reduction in the length of the ammocoetes passing through the rest period may be associated with a non-feeding phase of this period. Dr. Hubbs has suggested that no food is taken following the onset of general metamorphosis and has associated this absence of feeding with the length reduction during metamorphosis. It is probable that no food is taken for a short period before metamorphosis can be detected by external characters. My suggestion here is based upon the fact that my material shows the intestine to be empty and reduced almost to a thread when the external changes of transformation first appear. However, examination of the intestinal contents of twelve large ammocoetes killed at the stream June 10, 1936, show numerous diatoms and other small algae in all. These specimens range from 128 to 140 mm. in length and it is almost certain that some of them would have transformed during the following August. My material killed during July and early August is insufficient to determine the exact character of the non-feeding phase of the ammocoete rest period. It is suggested that such a phase exists for a short time at least before metamorphosis becomes general and that a length reduction occurs even before the transformation season is reached.

Whereas all the facts relating to the duration of the ammocoete stage are not known, the available data suggest a usual six year and three month period for the Tippecanoe River forms. This is assumed from the following review. *First,* four rather compact size groups occur which rather clearly indicate four successive spawnings. *Second,* a fifth group represented as five years old in June obviously reach the average length of transforming individuals by the time of the transformation period in August and September. *Third,* of the group within the limits of transformation size, only about one-third do transform, but approximately half of those within the upper range transform. Upon this basis, it may be suggested that the individuals of large size (130–150 mm.), but not transforming, are five years and three months old and entering the rest period; those transforming have passed this age by one year; while a number of smaller individuals are but four years and three months and represent the largest of that brood.

Although length data alone allow the possibility of transformation of individuals entering the sixth year, metamorphosis at this time would be precluded by the intervention of the ammocoete rest period. Upon length basis alone, it would also be possible for transformation at four years and three months. It seems more likely, however, that a variation of growth rate between individuals of the same brood account for a probable inclusion of these smaller individuals within the transformation size group. It is also probable that these are the individuals which reach a length of 150 mm. by the next

spawning season and yet have a rest period to pass. There is a further possibility that some individuals may persist as ammocoetes beyond the indicated transformation age of six years and three months. No absolute critera are yet available for determining actual age as applied to one single large ammocoete, and nothing is definitely known of the factors which bring about transformation in the lamprey. From my thyroid studies, however, there is strong evidence that a peculiar differentiation of the endostyle always occurs during the year indicated as a rest period.

My studies on the thyroid gland of *I. fossor* (1939) show a formation of unique semi-follicles within the endostylar organs of a large percentage of the ammocoetes of transformation size, which appears to be associated with the resting period even in its early phase. The fate of the semi-follicles in the Tippecanoe River specimens suggests that they represent the transformation tissue. These studies support the view that a definite resting period exists and that the period is characterized by a specialized differentiation rather than by growth in length. More definite conclusions on this phase can be made only by a statistical treatment involving the examination of a large number of animals.

External Changes During Transformation

(Text figs. 1–3; plate I, figs. A–F)

The following changes are first evident in transforming animals. These are listed in the order of the general sequence of appearance and reliability in determining metamorphosis.

(1) A more decided pigmentation of the eye region appears, and a yellow coloration becomes prominent along the base of the dorsal fin. A tan color of larvae prior to transformation time usually indicates that the animal will transform. Transformation may occur, however, without any apparent change in color.

(2) Lateral lips tend to be reduced and the mouth takes on a tapered appearance.

(3) Dorsal fin becomes elevated and somewhat emarginate between the two parts.

(4) Ventral surface of the pharynx becomes silvery rather than slate.

(5) Velar apparatus (between mouth and pharynx), which "beats" synchronously with the gill movement, becomes reduced in size and ceases its movement (as seen in strong light).

(6) Tail terminates more sharply as caudal myotomes reduce in size.

(7) First pharyngeal arch becomes more prominent and junction of mouth and pharynx appears constricted.

(8) Gill openings become rounded in outline rather than angular.

(9) Naso-pituitary opening becomes more prominent and elevated.

(10) Body is somewhat "stouter" and movements are more rapid.

(11) Pineal body is more evident, and yellow in color.

(12) The endostylar organ seen through the skin on the ventral surface of the pharynx disappears and a mid-ventral depression usually appears between the mouth and pharynx.

These changes all occur while the animal still burrows and appear within a period of a month or less. Later external change is, in general, merely an advancement of the early change. However, the mouth passes through a more complicated history. The early constriction persists for approximately two months. At this time the mouth has a rather broad and relatively smooth circular rim, which is tentaculate internally. Near its center, the rudiment of the tongue becomes prominent about two months after transformation is first evident. The mouth next begins to expand and elongate, and approxi-

mately two months later (the middle of December) has practically reached the adult condition. The fully expanded mouth has approximately the same diameter as that of the pharynx (text figures 3a–3b). The mouth of the male is relatively larger than that of the female.

The early transformation of the mouth and the eye are about concurrent. There is no definite "macrophthalmia" stage as seen in certain lampreys, for the eye never becomes conspicuously enlarged, and a general silvery color is not assumed. In the first month of transformation, however, the eye appears somewhat "beady." Later, its periphery becomes outlined with a narrow light-colored band that seems to replace a portion of the early dark pigmentation. Because of this apparent color replacement, one might consider the early eye as slightly more conspicuous than the adult eye, (plate I, fig. F).

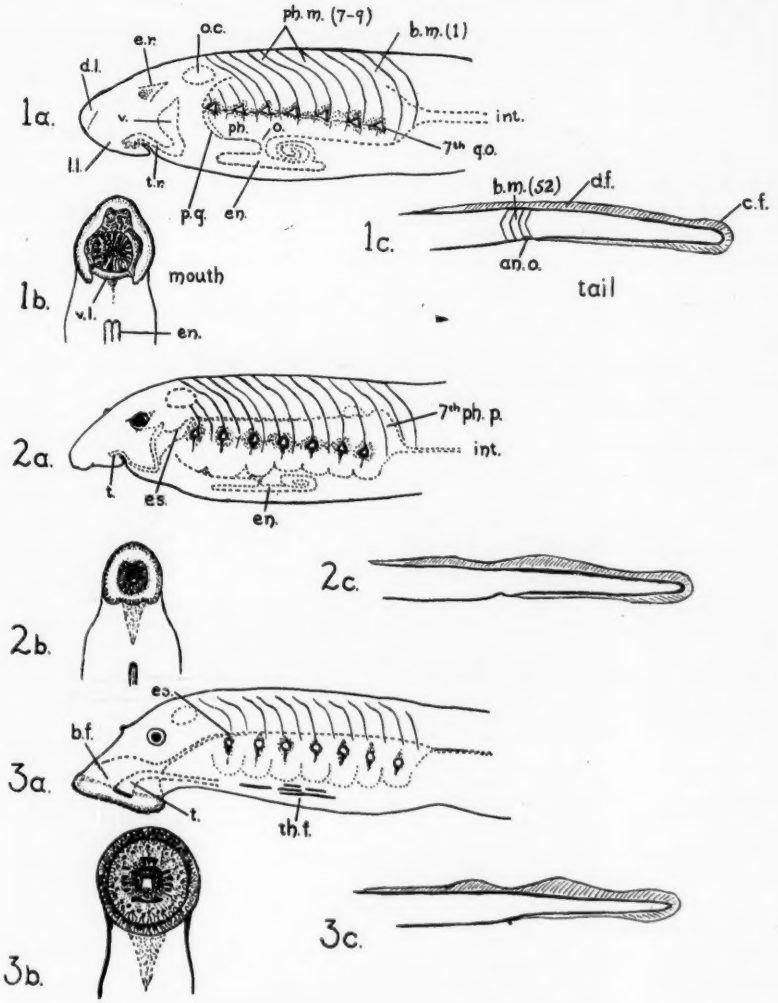
Internal Changes During Transformation

(Text figs. 1–3)

Internal changes in *Ichthyomyzon fossor* are similar to those which are commonly known for lampreys in general. However, at the onset of transformation, the intestine is already reduced from a diameter of 2 or 3 mm. almost to that of a thread. It contains no trace of food and resembles a flattened cord. The formation of the esophagus closely follows that of the adult type. As in other lampreys, it is formed from a grooved extension suspended along the mid-dorsal wall of the pharynx. Posterior to the second or third gill opening, the esophagus of *I. fossor* becomes a closed tube like that of other brook lampreys. In the adult condition the folded arrangement of the epithelium gives an appearance of collapse and adhesion. The separation of the esophagus from the new respiratory tube appears to be complete by early October. At this time, also, the sex of the individual can be readily determined by macroscopic examination of the gonad although no detailed study of this feature of development has been attempted here.

Changes in Behavior

Changes in the behavior of the animals are apparently closely associated with the physical changes. While the transforming individuals, at least in aquaria, remain in the burrows during the essential features of metamorphosis, they tend to leave the sand for longer intervals as the process advances. However, free activity does not become obvious until late January and early February. Some specimens refuse to bury themselves in the sand after the first part of January, while their mates, kept under identical conditions, are seldom seen out of the sand as late as the middle of April. However, it seems that a distinction should be made between the burrowing habits of ammocoetes and those of the transforming individuals. My observations indicate that the ammocoetes do considerable feeding at the mouth of the burrow without leaving the sand, whereas the position of the transformers indicates that they are merely hiding. The latter often have the entire pharynx extended above the burrow into which they quickly retract themselves when they are suddenly disturbed. The ammocoetes, when outside the burrow and when suddenly disturbed by one's turning a light on them, will reburrow by vigorous body movements. This striking characteristic tends



THE TRANSFORMATION OF *Ichthyomyzon fossor*

1 a-b-c, Morphological features of a fully grown ammocoete. 2 a-b-c, Structural changes during early metamorphosis. 3 a-b-c, Morphological condition of sexually ripe adult male. an.o., anal opening; b. f., buccal funnel; b. m., body myotomes; c. f., caudal fin; d. f., dorsal fin; d. l., dorsal lip; en., endostyle; es., esophagus; e. r., eye rudiment; int., intestine; l. l., lateral lip; o., orifice of endostyle; o. c., otic capsule; ph., pharynx; ph. m., pharyngeal myotomes; p. g., peripharyngeal grooves; t., tongue; th. f., thyroid follicles; t. r., tongue rudiment; v. l., ventral lip; 7th. g. o., seventh gill opening; 7th. ph. p., seventh pharyngeal pouch.

to diminish as transformation progresses. Transformation is probably complete when an individual abandons the behavior of the ammocoete. For my material this occurred, in general, in early February.

Sexual Maturity

In transforming individuals kept in aquaria over winter, full sexual maturity was not attained until late May and early June. This statement refers particularly to the two 1937–38 specimens from which the identification was made. These were kept in a cold stone cellar from October to spawning time. The temperature fell at intervals to 5°C. My 1938–39 transforming individuals have been kept in a cellar where the winter temperature has not been bebelow 12°C, and these in mid-April appear to be fully a month advanced over the 1937-38 specimens on that date last year. It is probable, however, that stream conditions were more closely approximated in the 1937-38 culture.

If it is assumed that the transformation process is complete only when the young lampreys tend to abandon their burrows, a period of about three or four months elapses between the completion of transformation and spawning. During the entire transformation and maturity period there is a further reduction in the length of the animal. On the basis of measurement of seven individuals, this reduction is estimated as about 10% of the length at the onset of metamorphosis. My 1938-39 data indicates that the two specimens from which the identification was made, and for which the table of characters was given, are considerably below the average length of the sexually mature adult. Four individuals of the 1938 collection now (mid-April) almost sexually mature, range in length from 118 to 136 mm. Upon the basis of the same degree of measured size reduction as exhibited for these four, the average length of the ten original 1938–39 transforming individuals would be approximately 125 mm. had they all been allowed to reach full sexual maturity. Measurements of representative specimens follow.

Table 3

Reductions in Two Specimens from Early Transformation to Sexual Maturity

Dates	Female		Male	
	Length	Weight	Length	Weight
Sept. 5, 1938	148 mm.	5.1 grams	132 mm.	3.4
Oct. 13, 1938	145 mm.	.....	130 mm.	....
Nov. 12, 1938	145 mm.	.....	127 mm.	....
Jan. 2, 1939	141 mm.	.....	127 mm.	....
Mar. 27, 1939	138 mm.	4.3	126 mm.	3.0
April 23, 1939	136 mm.	.....	123 mm.	....

The measurements were made by placing the animal in a shallow culture jar of clear water which was set over a ruler. The weights were made by transferring the animals in a sieve to the balance. Excess water was shaken off before the transfer was made.

The smallest sexually mature individual of this form reared in my aquaria was a female which measured only 92 mm., which was kept in pure washed sand for almost two years. Though original ammocoete measurement was not

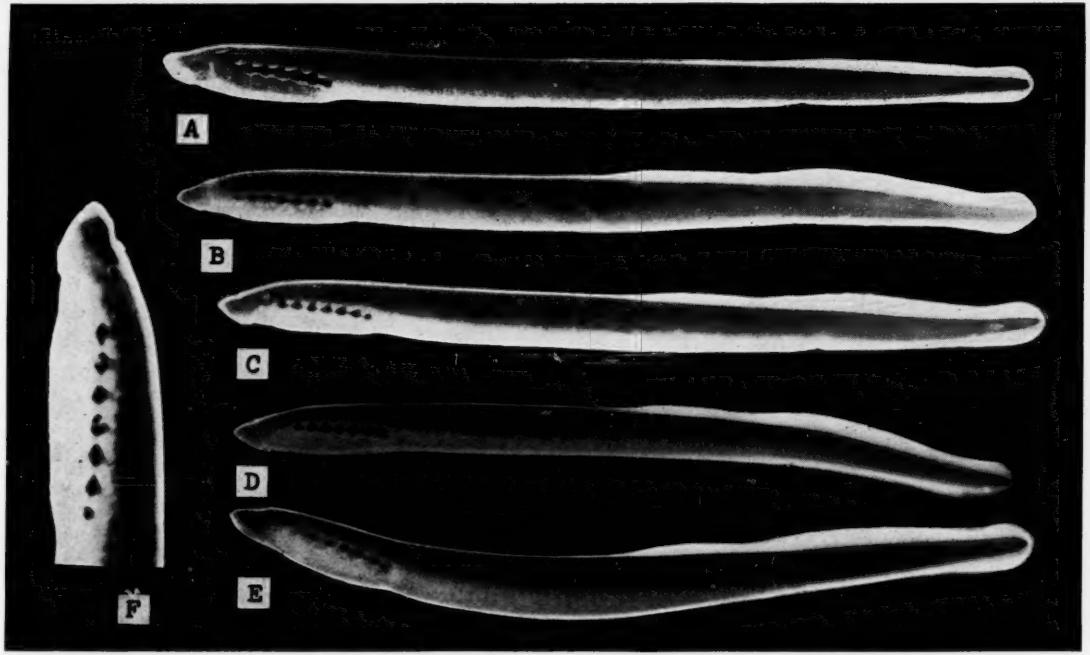


PLATE I

STAGES IN THE LIFE-HISTORY OF ICHTHYOMYZON FOSSOR FROM INDIANA

The photographs are of living animals anesthetized with carbonated water. Figures A to E are arranged to show relative lengths. The actual color of D and E is similar to that of B and C.

Fig. A. An ammocoete of September 1, 1938, that did not transform: considered to be just entering into the ammocoete rest period.

Fib. B. A transforming ammocoete of September 1, 1938. Transformation was first detected in this animal on August 25, 1938.

Fig. C. An immature adult of December 15, 1938. The animal had not yet left the burrow in the sand.

Fig. D. An active adult male of March 21, 1939. This animal was not seen to be burrowed after about the middle of the previous January.

Fig. E. An active adult female of March 21, 1939. This particular female had seldom left the sand up to the above date.

Fig. F. The head and pharynx of the animal of Fig C enlarged about 2½ times. The eye indicates that there is no definite macrophthalmia stage that is characteristic of other species of lampreys.

recorded, it was one of a group regarded as "of transformation size." The case is interesting in showing the ability of these animals to exist under conditions of extreme food scarcity, and in that a total reduction in body length of at least 30 mm. must have occurred. This female died in the aquarium in mid-May, when little more than a swollen bag of eggs. Although it measured only 92 mm., a total of 780 eggs was counted. The egg is approximately 1.2 mm. in diameter.

Spawning and Early Embryo

So far as can be determined, the normal breeding habits of this species have never been observed in the Tippecanoe River, at least, never at Warsaw. It is rather certain from June collections that spawning occurs late in May. The season is probably similar to that described by Reighard and Cummins (1916) for *I. fosser* in Michigan. Animals kept in aquaria over winter apparently lack some stimulus or vigor for normal spawning. However, fertile ova and sperm have been secured by milking out the gonads into vessels of water. The male and female from which the identification was made were probably the first lampreys reared in aquaria from the ammocoete stage to produce young, and certainly the first of the species. In previous observations at least seven individuals have died in aquaria at full sexual maturity without spawning; and the specimens from which fertile ova and sperm were secured appeared in a very weakened condition after being stripped. At the present time (mid-April) I have two live males and two females which appear extremely vigorous. The females are already much swollen with eggs.[2] With these it is intended to approximate closely stream conditions when full sexual maturity arrives. No definite information is thus far available on how long the animals normally live after spawning, but it is probably only a few days at the most.

The embryos resulting from the induced fertilization of the eggs of the aquarium reared adults were seen to develop in an extremely adhesive glue-like mass. They wriggle free from a mixture of sand and this substance at about twelve days, and for a time become free swimming individuals. Many attempt to burrow at about fourteen days after fertilization. Cleavage was extremely irregular and there was much variation in the rate of development. Proper aeration and sand appeared to be lacking and many were dying on the fifteenth day. Consequently, the young were killed and fixed.

The Life Stages

A general review of lamprey literature indicates a need for more specific definition of life cycle periods. The lack of such definition has tended to obscure the biology of the Petromyzontia in general. Life history information, and therefore, dependable identification of the material of earlier investigators is commonly lacking. This is particularly true of many anatomical investigations which refer to all species in the ammocoete stage as Ammo-

[2] These two females were killed May 20, 1939, one in an extremely weakened condition. They were first stripped of eggs, then fixed in Bouin's, and placed in 70% alcohol. Measurements after killing and preserving are: 112 mm., 1050 eggs; 122 mm., 1340 eggs. The 122 mm. specimen is the female of Table 3 and shows a reduction in length from 148 mm. as measured in the living condition September 5, 1938. The two males of this collection measured 114 mm. and 108 mm. The measurements of the three specimens (adults) taken from Tippecanoe River, May 14, 1939, by Dr. Hubbs are as follows: one female, 116 mm., and two males 104 mm. and 105 mm. No cleavage was obtained in the eggs of my material mentioned above, and it is assumed that maturation was incomplete since the sperm appeared mature.

coetes. In view of this, the following periods are suggested for the life cycle of *Ichthyomyzon fossor* as found in the Tippecanoe River of northern Indiana:

(1) An embryonic period of three or four weeks;

(2) An ammocoete growth period of usually five years;

(3) An ammocoete rest period of one year, the latter part of which includes a non-feeding phase;

(4) An early transformation period of two or three months, approximately between August 20 and November 20;

(5) An immature adult period of a semi-sedentary nature from about November 20 to February 20;

(6) An active early adult period leading to sexual maturity from about February 20 to May 20;

(7) A post-spawning adult period of undetermined duration, but probably lasting only a few days.

At least from the onset of transformation, no food is taken, and the gonads are entirely used up in the single spawning season.

Summary

1. The northern brook lamprey, *Ichthyomyzon fossor,* occurs in the Tippecanoe River, in Indiana. An aberrant condition of the supraoral cusps suggests that a form somewhat distinct from *I. fossor* may be represented. This species has not been previously reported from Indiana, nor has the peculiar dentition been previously reported for the species.

2. A study of the life cycle indicates that the usual ammocoete stage for the Indiana specimens lasts six years and three months. The statistical data upon a basis of ammocoete length alone, however, allows for the possible transformation of an animal of four years and three months. An ammocoete stage of more than the six year period is also possible judging from the available data.

3. The observations indicate that an entire year is normally spent (by large ammocoetes) during which time no increase in length occurs—no suitable information is available on possible changes in weight. The term "rest period" is suggested for this phase of ammocoete life cycle. It is suggested that within this period there is a phase of special differentiation which may be essential for the onset of the rapid and general metamorphosis. It is probable that a slight reduction in length occurs during the rest period.

4. The more conspicuous changes during transformation have been tabulated, and a more detailed definition of the stages within the life-cycle have been presented.

5. Sexually mature adults were reared in aquaria from the ammocoete stage. Eggs from these adults were reared to larval stage, probably the first to be obtained in this manner.

Literature Cited

Gage, Simon Henry

1927 The lampreys of New York state—life history and economics. *Supplement to Seventeenth Annual Report, State of N. Y. Conservation Dept., Biol. Surv. Oswego Watershed:* 176–177.

Hubbs, Carl L.

1925 The life-cycle and growth of lampreys. *Pap. Mich. Acad. Sci., Arts, and Letters,* 4, 1924: 587–703, figs. 16–22.

HUBBS, CARL L., AND TRAUTMAN, MILTON B.
1937 A revision of the lamprey genus *Ichthyomyzon*. *Misc. Publ. Mus. Zool Univ. Mich.*, 35: 1–109, figs. 1–5, pls. 1–2.
LEACH, W. JAMES
1939 The endostyle and thyroid gland of the brook lamprey, *Ichthyomyzon fossor*. *J. Morph.*, 65 (3): 550–605, Pl. 3.
OKKELBERG, PETER
1922 Notes on the life-history of the brook lamprey, *Ichthyomyzon unicolor*. *Occ. Pap. Mus. Zool., Univ. Mich.*, 125: 1–14, figs. 1–4.
REIGHARD, JACOB, AND CUMMINS, HAROLD
1916 Description of a new species of lamprey of the genus *Ichthyomyzon*. *Ibid.*, 31: 1–12, pls. 1–2.
SCHULTZ, LEONARD P.
1930 The life history of *Lampetra planeri* Block, with a statistical analysis of the rate of growth of larvae from western Washington. *Ibid.*, 221: 1–35, pls. 1–2.

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Seasonal Variations in Weight of Columbia River Chinook Salmon[1]

By WILLIS H. RICH

DURING the fall and winter of 1938–39 the writer, in collaboration with Dr. R. D. Calkins of the University of California and Dr. W. F. Durand of Stanford University, made a study of the fishery problems raised by the construction of the Grand Coulee Dam on the upper Columbia River. It fell to my lot, as the biologist of the group, to try to determine the relative importance of the salmon runs that have normally spawned in the Columbia basin above the site of Grand Coulee. In the course of this study it became important to estimate the number of salmon taken in the commercial fishery for the purpose of comparing this with the number counted as they passed the dam at Bonneville. The commercial catch is recorded as pounds landed and no complete and reliable figures are available as to the numbers of fish taken. It was necessary, therefore, to estimate the number of fish taken by dividing the poundage landed by the average weight.

Unfortunately there was no satisfactory information as to the average weight of Columbia River Chinook salmon, which species was of primary importance to the problem under consideration. It has been a general understanding for many years that the average weight of these fish is approximately 22 pounds, although the data on which this statement has been based are not, so far as we know, a matter of record. This figure was used as the basis for one series of estimates given in the report of the Board. However, it is well known that there are fairly wide seasonal fluctuations in the weight of Chinook salmon during the several months that these fish are running in the

[1] Contribution No. 5, Department of Research, Fish Commission of Oregon.

Columbia. It seemed important, therefore, to try to adjust for this fluctuation. After various inquiries it seemed reasonable to believe that an estimate of the number of fish taken in the fishery based on an average weight of 15 pounds for May, of 20 pounds for June and of 25 pounds for the remainder of the season would come nearer the true figure than would an estimate based on an average of 22 pounds throughout the season. A second series of estimates based on these figures was therefore given, although it was fully recognized that neither series was above criticism. There were, naturally, considerable differences in the estimates arrived at on these two bases, especially for certain portions of the season, but these differences seemed not to be serious for the immediate purposes of the study of which they formed a part.

For the sake of more satisfactory conversion figures that could be used in a revision of the study of the salmon runs of the Columbia of 1938 and for future similar studies of the runs of other years, an attempt was made during the season of 1939 to accumulate data providing more accurate estimates of the average weights. The results have proved to be of considerable interest and are presented herewith.

The data were secured through the kind and effective cooperation of a number of the canning companies who, through their receiving stations, recorded counts of the number of Chinooks delivered as well as the weight. Our thanks for this assistance are due especially to the Columbia River Packers Association, the Columbia River Salmon Company, P. J. McGowan and Sons and the Union Fishermen's Cooperative Packing Company. From some of these companies almost complete records were secured from the time that counts were started to the end of the spring season on August 25. From others samples only were counted each week. On the whole the data secured from the different companies were remarkably uniform (with certain exceptions that will be mentioned) and there seems every reason to believe that they present a fairly accurate picture of the variations in weight of the commercial catch during the spring season of 1939.

For the purpose of showing the reliability and consistency of the data as well as significant variations, the details are given in the following tables so far as necessary. These tables show the number of fish counted and the average weight for (1) each week, (2) each company and (3) each receiving station.

Data given by Calkins, Durand and Rich show that between 85 and 90 per cent of the poundage of Chinook salmon taken from the Columbia River catches during the spring season of 1938 were taken in the lower 40 miles of the river, opposite Pacific and Wahkiakum counties, Washington (Zones 1 and 2 in the Oregon records). It is obvious, therefore, that the data given in Tables 1, 2, and 4 are of primary importance in determining the trend of weights in the commercial catch. The data of Table 4, for reasons that will appear, are not directly comparable with the others so that those of Tables 1 and 2 remain as the best available for the purpose. Examination of these will show a quite remarkable uniformity in spite of the fact that several companies and numerous individuals were concerned with their collection.

These data, on which is based our best estimate of the seasonal variations

in weight, are presented graphically in Figure 1. The mean weights determined from the combined data given in the last column of Table 2 are indicated by the solid circles and the range within which fall all of the component means derived from data secured from individual stations or companies is shown by the short horizontal lines placed above and below the circles. This range is short and entirely consistent with the grand means shown by the circles. This consistency is, we believe, proof that the general averages and the trend to be mentioned below show reliably the changes in weight that occurred during the spring season of 1939—particularly in view of the large numbers of fish that entered into the determinations.

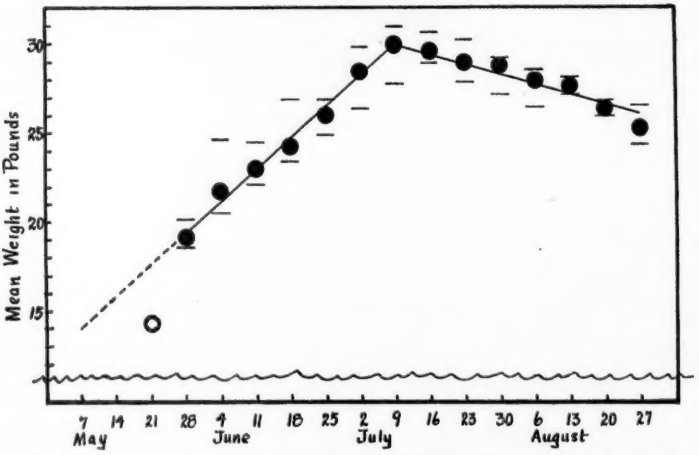

Fig. 1. Variation in weight of Chinook salmon taken on the lower Columbia River during the spring season of 1939.

The circles are the weighted means derived from all data given by companies "A", "B" and "C". The short, horizontal lines above and below each circle show the limits within which fell all of the individual means from the different stations and companies. The open circle for May 21 was based on only nine fish. The straight lines passing through the "swarm" of circles is the trend (see text).

The straight lines of trend shown in Figure 1 have been fitted to the average weights given in the last column of Table 2. One line fits the data for the weeks from the beginning of the series up to and including the week of July 9. The intercepts on the July 9 ordinate are 30.0 pounds for the first including, again, the figures for the week ending July 9. Using the method of averages the slope of the line fitting the data for the first part of the season was found to be +1.78 and that for the line fitting the data for the last part of the season —.60. The greatest average weight obviously comes in the week of July 9. The intercepts on the July 9 ordinate are 30.0 pounds for the first half of the season and 30.2 for the last half. If, for convenience, we assume that the intercept for the last half of the season also came at 30 pounds (a minor change) the slope for the last part of the season becomes —0.55. This has the advantage of giving the two lines of trend a common point at 30 pounds on the July 9 ordinate which may then be taken as the origin on the

time axis. On this basis the equation for the trend for the period previous to the week of July 9 is $y = 30 + 1.78x$ while that for the last half of the season is $y = 30 - 0.55x$, in which y is the estimated average weight and x the week with origin at July 9.

TABLE 1

AVERAGE WEIGHTS AND NUMBER OF FISH COUNTED AT FOUR STATIONS OF COMPANY "A" ON THE LOWER COLUMBIA NEAR ASTORIA

1939 Week Ending	Station 1		Station 2		Station 3		Station 4		Total	
	No.	Mean Weight	No.	Mean Weight	No.	Mean Weight	No.	Mean Weight	No.	Mean Weight
May 28	53	18.6	43	19.7	15	20.1			111	19.2
June 4	235	21.0	158	20.5	23	24.6	198	22.9	614	21.6
11	184	22.1	152	22.7	60	24.2	225	24.5	621	23.3
18	269	24.8	178	23.8	63	25.3	247	26.9	757	25.0
25	458	24.9	347	25.9	141	26.9	615	26.8	1,561	25.8
July 2	335	28.4	196	26.4	125	29.2	303	29.9	959	28.6
9	335	27.8	224	28.5	191	31.1	572	31.0	1,322	29.9
16	348	30.7	244	29.3	226	29.2	878	30.2	1,696	30.0
23	225	27.9	102	28.7	78	30.2	475	29.8	880	29.2
30	650	29.0	274	28.8	403	29.0	1,129	29.0	2,456	29.0
Aug. 6	788	27.6	430	28.0	407	27.7	1,613	28.6	3,238	28.1
13	2,342	27.2	1,320	28.2	897	28.1	2,785	27.8	7,344	27.6
20	2,462	26.3	1,064	26.8	1,291	26.2	377	26.2	5,194	26.4
27	4,329	25.7	792	26.6	1,793	24.4			6,914	25.4

TABLE 2

AVERAGE WEIGHTS AND NUMBER OF FISH COUNTED AT SEVERAL STATIONS OF TWO COMPANIES ON THE LOWER COLUMBIA NEAR ASTORIA, AND THE TOTALS FOR COMPANIES "A", "B", AND "C"

1939 Week Ending	Company "B"		Company "C"		Totals for "A", "B", and "C"	
	No.	Mean Weight	No.	Mean Weight	No.	Mean Weight
May 21	9	14.3	...	...	9	14.3
28	94	18.9	...	...	205	19.1
June 4	184	21.9	...	...	798	21.7
11	271	22.2	...	...	892	23.0
18	305	23.4	645	23.6	1,707	24.2
25	468	25.7	898	26.5	2,927	26.0
July 2	383	28.0	1,294	28.8	2,636	28.5
9	494	29.1	1,152	30.5	2,968	30.0
16	356	29.5	1,225	29.0	3,277	29.6
23	351	28.6	717	28.7	1,948	29.0
30	164	27.2	1,411	28.7	4,031	28.8
Aug. 6	323	26.5	179	27.5	3,740	28.0
13	1,072	28.0	...	...	8,416	27.7
20	775	26.6	...	...	5,969	26.4
27	856	24.4	...	...	7,770	25.4

We fully appreciate the fact that this method of fitting a "curve" to observational data is entirely unorthodox since it involves the use of two curves instead of one—no matter how complicated that one might have to be to give a satisfactory fit. But, since the purpose is only to graduate the data without any attempt to develop a rational equation (a difficult if not impossible task) and, since the combination of these two straight lines fits the observations remarkably well we see no reason for avoiding the method. The

chi-squared test has been applied to estimates of the number of fish in the samples that were obtained by dividing the recorded weight received by the estimated average weight as determined from these equations, these estimates then being compared with the actual counts. The test shows that the fit

TABLE 3

AVERAGE WEIGHTS AND NUMBER OF FISH COUNTED AT STATIONS BETWEEN ST. HELENS, OREGON, AND BONNEVILLE DAM AND OF FISH TAKEN AT CELILO FALLS

1939 Week Ending	St. Helens–Bonneville		Celilo	
	No.	Mean Weight	No.	Mean Weight
May 28	16	16.0	94	14.2
June 4	35	18.2	50	11.2
11	46	19.1	20	14.1
18	65	21.4	9	14.2
25	45	26.0	5	7.0
July 2	139	23.6	2	21.0
9	169	27.5	..	...
16	444	27.7	..	...
23	136	27.5	..	...
30	114	24.9	20	26.3
Aug. 6	...	...	..	...
13	93	22.4	69	17.3
20	288	22.2	108	24.6
27	217	17.4	...	...

TABLE 4

AVERAGE WEIGHTS AND NUMBER OF FISH COUNTED BY COMPANY "D" ON THE LOWER COLUMBIA FOR 1938 AND 1939

Week Ending	1938		1939	
	No.	Mean Weight	No.	Mean Weight
May 7	168	17.2	224	17.0
14	158	16.6	128	19.2
21	74	17.8	21	21.1
28	8	19.2	24	22.2
June 4	29	23.0	60	27.8
11	26	21.4	39	27.4
18	122	26.8	45	28.6
25	31[1]	27.8	158	29.9
July 2	134	29.4	87	31.2
9	113	29.0	196	31.0
16	225	29.4	265	31.3
23	203	28.7	443	29.5
30	504	28.7	432	29.8
Aug. 6	1,164	28.2	1,086	29.6
13	857	27.6	1,470	28.5
20	1,109	27.4	1,143	28.4
27	610	25.0	2,486	26.9

[1] Data for one day of this week omitted because obviously a typographical error had been made in the record.

secured by using these two straight lines is entirely reasonable. (P lies between .20 and .30.) The data were also fitted by an orthogonal polynomial of the third degree using the methods of R. A. Fisher, but the results were obviously not satisfactory and it has seemed hardly justified to go on to fitting with polynomials of higher degree. For the third degree equation the chi-squared test, made on the same basis as that for the fit of the two straight lines, gave a P value between .01 and .02.

On the basis of these two equations the following table (Table 5) has been prepared, showing the estimated average weights for each week of the 1939 spring season. Since the first three weeks of the season were not adequately represented in the data we have extrapolated to get tentative estimates for these weeks. In Figure 1 this extrapolation is shown by the broken part of the line of trend.

TABLE 5

ESTIMATED AVERAGE WEIGHTS FOR EACH WEEK OF THE 1939 SPRING SEASON BASED ON THE TWO LINEAR EQUATIONS GIVEN IN THE TEXT

Week Ending	Estimated Average Weight
May 7	13.98[1]
14	15.76[1]
21	17.54[1]
28	19.32
June 4	21.10
11	22.88
18	24.66
25	26.44
July 2	28.22
9	30.00
16	29.45
23	28.90
30	28.35
Aug. 6	27.80
13	27.25
20	26.70
27	26.15

[1] Extrapolated.

These data indicate that during the first week of May the average weight was probably about 14 pounds and that the weight increased regularly at the rate of 1.78 pounds per week up to July 9, at which time the maximum average weight of 30 pounds had been attained. After this time the average weight declined at the rate of 0.55 pounds per week to the end of the spring season on August 25 at which time the average weight was approximately 26 pounds.

It is important to note that these figures apply only to the Chinook salmon taken in the commercial catch in the lower part of the river during the spring season. They do not apply to the run of Chinooks as a whole, to the fish that are caught in the upper reaches of the river, or to those that escape the commercial fishery and ultimately reach the spawning grounds. Furthermore, a very large percentage of the fish on which the study is based are taken by gill nets—a type of gear that is highly selective, depending upon the size of the mesh employed. The size of mesh used varies greatly during the season, smaller-meshed nets being used when the smaller fish are running and larger-meshed nets replacing them as the fish get larger. The average size of the fish in the commercial catch is, therefore, the resultant of the actual change in the size of the fish as the season advances plus the effect of changes in the size of mesh used in the gill nets. The changes in the average size of the fish are doubtless due partly to growth and also to changes in the stocks

forming the run, with resulting changes in the age-group composition, etc. The exact percentage of fish that were captured by gill nets for our samples is not known but it was undoubtedly high. But the percentage of the total catch made by gill nets is also high, especially in the lower river. In recent years this percentage of Chinook salmon taken by drift gill nets alone has been close to 70 per cent, as given by the Reports of the U. S. Commissioner of Fisheries—appendices on the Fishery Industries of the United States. We believe, therefore, that our data are representative in this respect of the catch in the lower river as a whole and that the average weights given in Table 5 may be used properly in estimating the number of fish in the catch from the record as given in pounds.

It has been of interest to estimate the average weight for the entire spring season to compare with the generally accepted estimate of 22 pounds for the Columbia River Chinook. Because the 1939 catch figures are not yet available we have weighted the estimated weights as given in Table 5 by the poundage reported for each week as given in Table 1 of the report by Calkins, Durand, and Rich. The resulting mean is 25.6 pounds. Although the method necessarily used in arriving at this figure is not entirely satisfactory, the result at least serves to indicate that the average weight of fish in the commercial catch is noticeably higher than is usually thought. It is quite likely that, in earlier years, before the smaller, early fish were so seriously depleted and the later running fish were not so eagerly sought, the mean weight of the fish in the commercial catch was approximately 22 pounds; but apparently that is not true today.

The data for the two upper portions of the river as given in Table 3 are shown graphically in Figure 2. For comparison, the line of trend is given as determined for the lower river and it is repeated twice—moved to the right so that it falls, respectively, one week (dashes) and two weeks (dots and dashes) later in the season. Calkins, Durand, and Rich have shown that, in general, the fish taken in the region from St. Helens to Bonneville in any given week were in the lower river the previous week and will be in the region of Celilo the following week. The trend shown by the line of dashes, then, is to be compared with the data from the region St. Helens to Bonneville while the trend shown by the line of dots and dashes is to be compared with the data from Celilo.

In the middle river, from St. Helens to Bonneville, the observed average weights parallel the trend (line of dashes) quite well for the first half of the season—up to about July 16—but the observations fall, with only one exception, below this trend by about a pound and a half in the average weight. The average weights drop after July 16 just as those on the lower river dropped after July 9, with the difference that the decrease in weight in the middle river is much more rapid, so that, by the end of the spring season, the average weight is only about 20 pounds as compared with over 26 pounds on the lower river. Some of these apparent differences between the fish taken in the middle river and those taken in the lower river may be due to the fact that the samples from the middle river are much smaller than were those for the lower river and, therefore, the averages are less reliable. It is clear, however, that there is a distinct tendency for the fish taken in the middle river

to average less. This is undoubtedly due at least in part to the selective action of the gill nets operated on the lower river which have tended to take out the larger fish. It may be due also, in part, to loss in weight during the interval between the time the fish were in the lower river and the time they reached the middle river. We can offer at this time no explanation for the apparently more rapid decrease in the average weight during the latter part of the season unless, as suggested above, it is due to "sampling error."

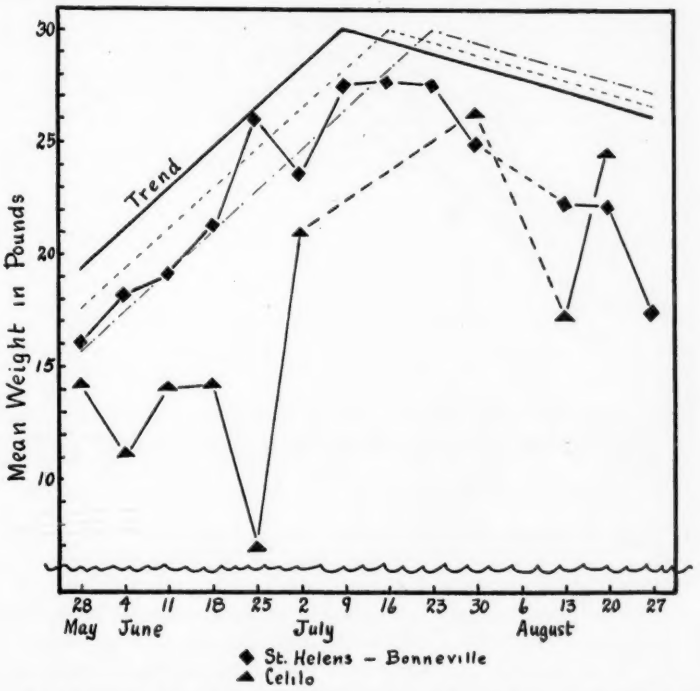

Fig. 2. Variation in weight of Chinook salmon delivered between St. Helens and Bonneville and at Celilo.

The data from Celilo are not satisfactory on account of the small numbers of fish in the samples, and also because there are rather wide gaps in the data. However, when compared with the appropriate trend (the dot and dash line in Figure 2) the average weight shows a tendency to rise during the first part of the season and to fall during the last part. In general the variations at Celilo appear to parallel those in the other parts of the river but the weights are much lower, especially during May and June. The same reasons given for the fact that the average weights in the middle river were lower than those for corresponding periods on the lower river undoubtedly apply in still greater degree to these data from Celilo, but there is the further fact that a large, but unknown, percentage of the fish in the samples were taken by dip

nets and not by gill nets, and the dip nets are not selective in the same way as are the gill nets. The data are not, therefore, strictly comparable. About all that can be stated definitely is that the fish caught at, or near, Celilo show seasonal changes somewhat similar to those observed in the lower river but that the general average is much lower—perhaps as much as 5 pounds less than fish taken in corresponding periods in the lower river.

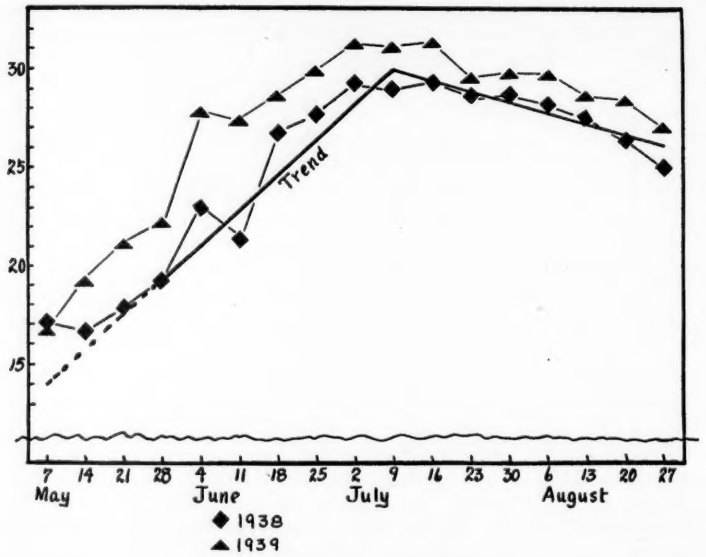

Fig. 3. Variation in weight of Chinook salmon delivered on the lower Columbia to Company "D" during the seasons of 1938 and 1939.

The data from Company "D," Table 4, are shown graphically in Figure 3, together with the trend as determined from the other data from the lower river. The remarkable thing about these is the fact that the 1938 data agree exceedingly well with the calculated trend while those for 1939 consistently lie above the trend and above the figures for 1938. During May and June this difference is, generally, between 3 and 4 pounds (approximately 15%). During July and August the difference is only about half as great but it is equally as consistent.

This difference is rather difficult to understand, but it is definitely *not* due to a confusion of the data—that has been checked. It is possible that this company, through some random or intentional selection of fishermen in 1939, received fish throughout the season that averaged heavier than those received by the other companies from which data were secured.

Whether the same condition existed in 1938 or not, we do not know, as there are no data from the other companies for that year. It would seem, on the face of this record, that there are fairly large fluctuations in average weight from year to year, but that the seasonal fluctuations within each year

follow the general pattern shown by the lines of trend that we have accepted as descriptive of the 1939 run. It certainly would not be astonishing if there were differences from year to year, not only in the general level of the average weights but also in the time at which the maximum weight for the season is attained, and the rate of change.

It is hoped that additional information can be had in future years that will make it posible to improve the estimates made here and will throw light on the extent and nature of annual fluctuations.

LITERATURE CITED

CALKINS, R. D., W. F. DURAND and WILLIS H. RICH
Report of the board of consultants on the fish problems of the upper Columbia River. *Mimeographed by U. S. Bureau of Reclamation, Denver, Colorado.*

FISH COMMISSION OF OREGON, PORTLAND, OREGON.

The Use of Hormones for the Conservation of Muskellunge, *Esox masquinongy immaculatus* Garrard[1]

By ARTHUR D. HASLER, ROLAND K. MEYER and HOWARD M. FIELD

THROUGHOUT the United States the construction of irrigation or power dams has created a problem in the conservation of fishes that depend upon migration up stream to gain appropriate spawning ground. In many instances inefficient or no fishways have been provided that would permit a complete negotiation of the stream; consequently the reproductive potentialities of these fish are lost to the maintenance of an adequate population.

This paper deals with a problem of this nature on the Chippewa River near Winter, Wisconsin, where a power dam obstructs the passage of muskellunge, among other fish, from ascending the river to the flowage areas where many of them have found appropriate spawning areas in the past. As the muskellunge begin their spring migration in this river, they attain the site of the dam where they "fight" the strong current, and mill around for several weeks in an attempt to reach the spawning grounds further up stream. Eventually they lose their spawning urge and return to the lower waters of the river without completing their normal reproductive function.

[1] In co-operation with the Wisconsin Conservation Department. Aided also in part through funds made available by the Wisconsin Alumni Research Foundation and the University of Wisconsin W.P.A. Natural Science Research Program.

Last year (1938) Wisconsin fish culturists, by seining, captured several muskellunge as they reached the dam, placed them in a shallow pond and observed the effect of artificial environment on induction of the spawning reaction. Apparently this confinement had a negative effect, as no eggs could be obtained. Since the females remained "hard" in the river below the dam and also in the pond, it was evident that some stimulus, either physiological or environmental or both, was necessary to cause ripening of the ovaries. Furthermore, the fish culturists interested in propagation of muskellunge have found difficulties in procuring spawn from fish inhabiting lakes. It appears that the females will not give their spawn artificially when caught on the spawning areas unless it happens that the ovary on that particular day is soft and in a spawning stage. If, however, the fish are netted before this "soft" period and held in pens, there is a tendency on the part of the fish to retain its eggs.

Since the authors (1939) induced spawning prematurely in trout as much as two months in advance of the normal spawning period by injecting fresh or acetone dried pituitary glands of the carp, it was assumed that similar treatment of these "captive" muskellunge of the Chippewa River would cause them to release their spawn. Furthermore, if the eggs could be procured, hatched, and the fry returned to the original waters, a contribution would be made toward maintaining the population, a matter of decided economic importance to this section of northern Wisconsin.

In the results that follow, it is shown that substances contained in the pituitary gland of the carp overcame the "hard" condition of captive muskellunge females and made possible the stripping of eggs which were hatched artificially.

Procedure and Results

At the Chippewa Flowage State Fish Hatchery, located at Winter, Wisconsin, migrating muskellunge were seined from the apron of the dam on the Chippewa River and transferred to a shallow pond (1 to 3 feet deep, 70 feet long and 40 feet wide). It was divided into two sections by a fence to keep control fish separated from experimentals. As the muskellunge were netted up and transferred to the pond section, the experimental females each received an intraperitoneal injection of 50 mg. of acetone dried pituitary glands of the carp, suspended in 3 cc. of water. For every female that was injected, tagged and placed in section 1 of the pond, another was tagged and placed untreated in section 2. By the end of the muskellunge "run" in the river there were eleven females in each half of the pond, in addition to a surplus of males (twenty-six) which were not treated because milt was readily obtained for fertilizing the eggs at any time during the experiment.

The first fish were injected April 29, 1939, and the last, May 6, 1939. The temperature in the pond varied from 14.8 to 18.5° C. The oxygen content of the water in the pond did not drop below 7 p.p.m. at any time during the experiment. The maximum length of females was 45½ inches (115.5 cm.) and the minimum length was 35 inches (88.9 cm.).

After injection the fish were tested daily by experienced spawn-takers Uninjected fish were seined up and handled the same number of times as the treated fish.

Table I shows that nine of the injected females spawned three to four days after a single injection of carp pituitary, while two were given two injections each and spawned six days after the first injection. Each of the injected females gave eggs. The eggs were fertilized, placed in hatching jars, where a normal hatch was reported by the hatchery employees. The fry were planted in the flowage waters.

None of the controls spawned during the experimental period. They were returned to the river May 20, 1939, without having released their eggs.

Fish No. 10 died of injuries acquired from battering at the dam and subsequent handling. This was the only mortality during the experiment.

TABLE I

SPAWNING RESULTS FROM MUSKELLUNGE INJECTED WITH CARP PITUITARY GLANDS

No.	Length in Inches	Date of Inject.	Dose in mg.	Date of Spawning	No. of Eggs Obtained
1.	36	4/29/39	50		
		5/ 3/39	50	5/ 5/39	25,250
2.	46	4/30/39	50	5/ 5/39	
		5/ 3/39	50		72,056
3.	37½	4/29/39	50	5/ 3/39	69,432
4.	42	4/29/39	50	5/ 2/39	100,992
5.	43	4/29/39	50	5/ 5/39	119,928
6.	39½	5/ 2/39	50	5/ 5/39	88,368
7.	43	5/ 2/39	50	5/ 5/39	75,744
8.	39½	5/ 2/39	50	5/ 5/39	72,688
9.	43½	5/ 6/39	50	5/ 9/39	69,432
10.	45½	5/ 6/39	50	5/ 9/39	44,184
11.	44½	5/ 6/39	50	5/ 9/39	164,112
				5/10/39	22,092
		CONTROLS			
1.	40	4/30/39	..	.....	0
2.	42	4/30/39	..	.....	0
3.	43	4/30/39	..	.....	0
4.	39	5/ 6/39	..	.....	0
5.	40½	5/ 6/39	..	.....	0
6.	35½	5/ 6/39	..	.....	0
7.	34	5/ 9/39	..	.....	0
8.	40	5/ 9/39	..	.....	0
9.	44	5/ 9/39	..	.....	0
10.	43	5/ 9/39	..	.....	0
11.	42	5/ 9/39	..	.....	0

DISCUSSION

The results of "forced" spawning we obtained from treating captive muskellunge with pituitary hormones of the carp simulate closely the finding of von Ihering (1935, 1937) who caused release of eggs from some Brazilian fishes (*Prochilodus, Astyanax* and *Hoplias*) upon injection of pituitary glands of fish of the same species at a time of the normal breeding season. He reported that the spawning response appeared to be stimulated normally by the first rains of the wet season which follow a long period of drought. In these South American fish the pituitary glands supplied the stimulus that precipitated spawning, where normally this stimulus was brought about by the onset of the rainy season.

The resistance to spawning of the muskellunge in captivity simulates the

"dry season" refractoriness of the Brazilian fish. Additional pituitary substance introduced by injection overcomes this refractoriness in both species.

On the other hand our studies with rainbow trout showed that this species could be made to spawn at least two months in advance of the normal spawning time, provided injections are started that early. Our work here, however, did not include experiments to show if this were possible with muskellunge.

While this work is of considerable physiological importance there are also certain features which make the methods here used of value in the conservation and management of fish populations in streams obstructed by dams, permitting the preservation of this species until arrangements can be made for fishways to be constructed around the dams, allowing them to pass to natural spawning grounds.

Literature Cited

Hasler, A. D., R. K. Meyer and H. M. Field
1939 Spawning induced prematurely in trout with the aid of pituitary glands of the carp. *Endocrinology* (in press).

Ihering, R. von
1935 Die Wirkung von Hypophyseninjektion auf den Laichakt von Fischen. *Zool. Anz.*, 111: 273–279.

Ihering, R. von and P. de Azevedo
1937 Ueber die Wirkung des Saugetier-Hypophysenhormons auf den Laichakt der Fische. *Ibid.*, 120: 71–75.

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Notropis perpallidus, a New Minnow from Arkansas

By Carl L. Hubbs and John D. Black

During the course of an ichthyological survey of Arkansas the junior author has collected two specimens which obviously represent a very distinct, hitherto unknown species referable to the large genus *Notropis*. In its extreme pallor (suggesting the scientific name *perpallidus* and the vernacular, colorless shiner), and in the large size of the few remaining melanophores, it is matched only by a technically very distinct form, *Notropis volucellus buchanani* Meek. That shiner has only 8 anal rays and 4—4 teeth.

The systematic relationships of *Notropis perpallidus* are hardly discernible in the maze of species now included in the genus. In the general form, in the shape of the mouth, and in some other respects it rather closely resembles another southern Ozarkian species of similarly uncertain affinities, namely *Notropis ortenburgeri* Hubbs (*in* Ortenburger and Hubbs, 1927: 127; Hubbs and Ortenburger, 1929: 72–73). It differs from *ortenburgeri* in its pallid appearance, the presence of teeth in the outer row, the less elevated dorsal fin, and probably in the higher average number of anal rays (10 or 11 instead of 8 to 10).

When compared with other species of the same region, it perhaps most closely resembles *N. boops*. The depigmentation, higher number of anal rays (8 in *boops*), more flap-like mandible, and numerous other differences show that this similarity is superficial.

Compared with other species having as many as 10 or 11 anal rays and as many as 2 teeth in the outer row, *N. perpallidus* differs in its weaker pigmentation, its somewhat clavate mandible, and in various other details. The little-decurved lateral line and the regular squamation, with rather large scales before the dorsal, set it off from all members of the *Lythrurus* group (including *N. fumeus* and *N. notemigonoides*); otherwise it is rather like *N. u. umbratilis*. The dorsal fin is less posterior than in the species of the *atherinoides–rubellus* complex, other than the terete *N. photogenis*. Numerous features separate *N. perpallidus* from all species of the southeastern lowlands, including *N. hypselopterus* (*N. metallicus*) and its allies. The general frailness, more compressed body, and numerous other features render unnecessary any detailed comparison with *N. ariommus* and its subspecies (*ariommus, telescopus,* and *arcansanus*). Compared with *N. amabilis* of Texas and Mexico (*N. socius, N. megalops,* and *N. swaini* are synonyms), our new form differs in the more oblique mouth with blackened lips, in the much frailer texture, and in numerous other characters.

Notropis **perpallidus,** new species

The two known specimens of *Notropis perpallidus* were seined by John D. and Ruby Y. Black on June 20, 1939, in a very silty, weedless backwater of the Saline River (a Red River tributary), 5 miles north of Warren, Bradley County, Arkansas; in rolling country between the Coastal Plain and the hills. The water temperature at 2 P.M. was 86° F. The holotype, 30 mm. in standard length, is deposited in the University of Michigan Museum of Zoology, as Cat. No. 125991. The paratype, U.M.M.Z. 125992, is 29 mm. long. In the following description the determinations for the paratype, when different from those of the holotype, are entered in parentheses.

The body of this very frail shiner is rather strongly compressed: the depth of the body is 1.7 times the greatest width, and measures 5.2 (5.6) times in the length to caudal base; the head is slightly less than half as wide as long; when "stepped" downward from the highest point of the back, the greatest width extends just to the lateral line. The body is distinctly deeper near the middle of the trunk than at the origin of the dorsal fin, as the predorsal contour is rather strongly arched. The origin of the dorsal is a

little elevated. Posteriorly the dorsal and ventral contours gently converge in the long, slender urosome. The length of the caudal peduncle enters the head 1.2 times, and contains the least depth 2.0 (2.4) times.

The margins of the body merge evenly into the symmetrical and rather strongly arched dorsal and ventral contours of the head. The tip of the muzzle lies on a horizontal passing scarcely below the center of the pupil. The symmetrical appearance of the head is enhanced by the vertically submedian position of the eye: in lateral view the interorbital rises above the eye a distance at least half the depth of the head below the eye. The greatest depth of the head slightly exceeds the combined length of snout and eye, and is two-thirds the length of the head, which enters the standard length 4.1 times.

The mouth rises at an angle of about 40°. Toward the symphysis the mandible is somewhat hooked upward and backward, and its front edge is broadly U-shaped when viewed from below. The lower jaw consequently has a rather flap-like appearance as the mouth is opened and closed. The upper jaw is bent toward a horizontal position near the anterior end. Because of the direction of the two jaws anteriorly, the upturned end of the mandible is definitely included within the broadly rounded tip of the premaxillary. The jaws show a reduced obliquity at the posterior as well as the anterior end, so that in side view the mouth is distinctly sigmoid. As seen from below, the sides of the gape are somewhat curved outward posteriorly. The upper lip is coterminous with the snout. The lips are thin. Upper jaw 3.4 (3.6); length of broadly rounded snout 3.8 (4.0); eye just equal to least bony interorbital width, 3.2 (3.1); least suborbital width one-third eye. The pharyngeal teeth number 2, 4—4, 2 (1, 4—4, 1), and bear rather broad and deep grinding surfaces beneath the hooks.

Dorsal rays 8 (7); anal rays 11 (10); principal caudal rays 19; pectoral rays 14-14 (13-13); pelvics 9-9, including a rudimentary outer ray. The dorsal is inserted over the middle (or end) of the pelvic base, equidistant between base of caudal and a point one pupil's length behind (or one pupil's length before) the tip of snout. The dorsal fin is moderately rounded; its depressed length is contained 1.7 (1.6) times in the distance forward to the occiput. The length of the short pectoral fin enters either the interspace between pectoral and pelvic insertions or the head 1.5 (1.4) times. The pelvic fin barely covers the anus; its length is contained 1.7 times in the head.

The scales are obviously very thin and deciduous. They are difficult to count, but by enumerating the scale pockets it is possible to arrive at a reasonably close approximation of the number: 7–34–4 (6–36–4), 2½ between lateral line and pelvic insertion, 18 (15) before the dorsal. The trunk scales seem to be somewhat elevated, but those of the lateral line are not much higher than the others. The lateral line is only moderately decurved, though rising rather abruptly toward the head: the distance between the pelvic insertion and the lateral line is contained 1.3 (1.5) times in the distance from the origin of the dorsal fin to the lateral line. Dermal structures indicate that the lateral line is probably complete.

The fish is very pale and frail. The flesh is distinctly translucent: the

myocommata show clearly by reflected light, the muzzle has a watery appearance, and the gills and the brain are visible through the bones of the head. The body as a whole is devoid of pigment. The lateral band is represented on the trunk by one very irregular, scattering row of large, stellate melanophores (almost lacking in the paratype), and on the tail region by about two very irregular rows of such specks. There is no definite caudal spot, but the basal part of the branched caudal rays, except for the median rays of the upper lobe, are separated by blackish streaks; the rudimentary caudal rays are clear of pigment. The axial septum is marked behind the middle of the trunk by a very fine, dashed line. The back before the dorsal fin bears about three very irregular rows of large, stellate, widely spaced melanophores. Such spots are clustered into a short stripe on either side of the median line immediately in advance of the dorsal fin. Along the middle of the base of the dorsal there is a conspicuous dark stripe composed of two series of black specks. On the back behind the dorsal there are two rows of well-scattered specks, showing a tendency to cluster just before the caudal fin. The holotype (but not the paratype) shows several giant melanophores on the mid-line of the belly. There is a cluster of such pigment spots just behind the anus, and there is a black speck near the base of each anal ray, with streaks extending a short distance upward and forward between the myomeres. A few linear melanophores form two irregular series behind the anal fin. Otherwise the body is virtually unpigmented. The dorsal, anal, and paired fins are entirely colorless. The top of the head is marked by large melanophores, each with a light ring between the broad dark center and blackish marginal fimbriae. These specks are thickly concentrated in a shield-shaped parietal blotch. The frontal region is devoid of pigment except for a a band on either side composed of 3 to 5 especially enlarged melanophores. A few specks on the opercle faintly represent a continuation of the lateral band. The anterior, median arch of the snout is darkened by scattered melanophores, and there is a group of giant color cells on the anterior part of the preorbital region. The lips are blackened and there are a few minute black specks between the rami of the mandibles anteriorly. Otherwise the head is almost completely clear of pigment spots.

Literature Cited

Hubbs, Carl L., and A. I. Ortenburger
1929 Fishes collected in Oklahoma and Arkansas in 1927. *Publ. Univ. Okla. Biol. Surv.*, 1: 45–112, pls. 6–13.

Ortenburger, A. I., and Carl L. Hubbs
1927 A report on the fishes of Oklahoma, with descriptions of new genera and species. *Proc. Okla. Acad. Sci.*, 6, 1926: 123–141.

Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Herpetological Notes

SOME NOTES ON THE BURROWS OF *PLETHODON METCALFI*.—In the course of some experimental work at the Highlands Biological Laboratory a great number of specimens of *Plethodon metcalfi* were needed. The writer was thus led to investigate their burrows to find a convenient productive method of collecting them. A shady spot on the side of Bearpen Mountain overlooking Lake Ravanel was chosen for study. An area of approximately 50 square yards, in which there was considerable undergrowth, many decaying logs and a heavy mat of leaves and loam, was laid off, and the tunnels laid open in the entire area. A small spade and a freshly cut and trimmed rhododendron limb were used to advantage in disclosing the burrows. Some 500 linear feet of burrows were followed.

The burrows are usually about an inch in diameter and lie parallel with and from 1 to 3 inches beneath the surface of the ground. They branch out in all directions and never end in a blind pocket. It was not unusual to follow a burrow into the root network of a rhododendron. Here it formed a labyrinth, extending over, under and along the roots at several levels. Numerous *Plethodon metcalfi* were caught in these labyrinths. Doorways were discovered at intervals opening from the tunnels to the surface; these opened for the most part under a log or a stone but often there was no covering. At intervals burrows extended almost vertically to the ground. A few of these were followed to a depth of about a foot but they extend much deeper. At rare intervals several tunnels met at one point to form a fairly large chamber. Grubs, beetles and myriapods were found on the tunnel floors. On dissecting the stomachs of the salamanders it was found that these constitute in large measure their food. The burrows, in addition to being places of refuge, are no doubt useful also as food traps during the day. Being nocturnal, the salamanders leave their burrows to forage only during the night. No other species of salamanders were found in the burrows, nor were any other vertebrates such as snakes or rodents to be found.

That the tunnels extend as deep as 10 to 12 feet in the ground can be proven by inspection of fresh road cuts. Although the earth is alternately rocky and sandy to this depth and filled with mica, openings to burrows are very numerous along certain deep cuts for roads leading into Highlands. It is along these cuts that *P. metcalfi* may be collected most abundantly at night. They may be caught after 9 P.M. as they leave their burrows, but are rarely seen earlier in the evening.

Although *Plethodon metcalfi* is well constructed for burrowing, having a pointed snout, heavy eyelids and strong neck muscles, the writer doubts that the burrows are dug by them alone. To test this point he duplicated as nearly as possible the terrain from which they were collected in a box in the laboratory. The salamanders were left here as long as three weeks without any evidences of burrowing. Even though they may not dig the burrows it is highly probable that they can extend and improve them.

The burrows are so characteristic of *Plethodon metcalfi* that they may be used as keys as to their presence. Wherever these burrows with their doorways exist on the Highlands plateau the writer always finds this salamander.—CLAUDE S. CHADWICK, *Vanderbilt University, Nashville, Tennessee.*

A RECORD FOR *EUMECES ANTHRACINUS* FROM GEORGIA.—In connection with a study of the herpetology of Maryland I was puzzled by a specimen of *Eumeces anthracinus* (Baird), C. U. No. 6375, recorded as from "Mountain City Gap, Maryland." There seemed to be no such place in Maryland, and on questioning Professor J. C. Bradley, who collected the specimen, it became clear immediately that an error had been made in cataloguing. The correct data is "Wilson Gap, near Mountain City, Rabun County, Georgia, August 22, 1913." The incorrect locality has been published at least once (Taylor, 1936, Univ. Kans. Sci. Bull. 23:386). The corrected locality constitutes a new record for the species in Georgia. —ROBERT H. MCCAULEY, JR., *Cornell University, Ithaca, New York.*

MATING POSTURE IN THE ALLIGATOR LIZARD (*GERRHONOTUS COERULEUS*).—Incidental to field work for the California Division of Fish and Game on the Mattole River near Thorn, Humboldt County, California (Humboldt: 4S; 2E; 31), the writer, on April 16, 1939, noticed beside a trail a pair of alligator lizards (*Gerrhonotus coeruleus* subsp.) in copulation.

When first seen the female was lying beneath the male. Her body was sharply recurved and her tail was looped onto that of the male, thence downward and beneath a thoracic bend in her body. The male lizard was standing over the thorax of the female with the left leg exposed. He held the female securely with the anterior cervical portion of her body in his mouth (see Fig. 1). The pelvic region of his body was at first apposed to that of the female as he grasped the basal portion of her tail firmly with his hind legs. When I moved closer, he relaxed his tight hold somewhat. His tail rested on the leaf-covered ground with the more distal two-thirds recurved somewhat around the fore part of the body of the female.

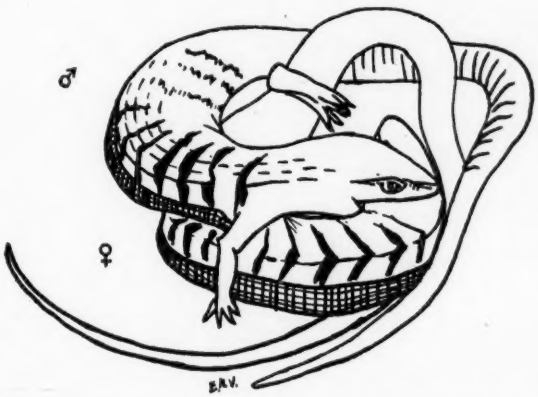

Fig. 1. Mating posture in *Gerrhonotus coeruleus*. The mate holds the anterior cervical part of the female securely in his mouth.

When I grasped both lizards, the male at once released his hold on the female and both tried to squirm away. Whitish areas of dried sexual products were observed about the cloacal openings of both reptiles.

Ticks (*Ixodes ricinus*?) were abundant in and about the external auditory openings and in the cervical folds on both lizards.—ELDEN H. VESTAL, *California Division of Fish and Game, Stanford University, California.*

BEHAVIOR OF *MICRURUS FRONTALIS FRONTALIS*.—The observations recorded below were made in the Department of Paraná, Province of Entre Ríos (Argentina), within a few miles of the city of Paraná. *Micrurus f. frontalis* (Duméril & Bibron) is included in the resident fauna of the district, but despite a long residence in the Province, and frequent excursions in likely places, this was my first encounter.

The specimen was collected on September 24, 1938, and my first impression was that the snake displayed a remarkable ability for concealing itself in spite of its warning coloration, but it was when it was maneuvered into an exposed patch of ground that it adopted tactics which struck me as being unusual and interesting. Once deprived of cover the coral threw itself into a number of coils and struck spasmodically towards my stick. It was, however, with its tail that it struck, its head being concealed under its coils. The last inch of the tail was curved into a small ring which gave the necessary breadth to give the rough appearance of a head. Seeing that this feint was coupled with some local movement I was able to observe that synchronized with the thrusts the hemi-

penis was extruded from the vent for a brief moment, giving the whole performance a sinister appearance as though some defensive organ were being brought into play. This procedure was repeated frequently the whole time that the snake was kept from cover. About a quarter of its length, at a rough computation, was employed in each lunge.

The behavior of this 24-inch specimen was decidedly threatening, but it never struck with the anterior portion of its body so long as it was not actually hurt. Its instinct was obviously to feint with its tail while keeping its head as concealed as possible. The identification of the specimen was confirmed beyond question as it was taken to the British Museum, S. Kensington. I believe that any casual observer would fail to notice, at any rate for a time, that it was with the posterior portion of its body that this snake struck.—C. E. ALLEN, *FF. CC. de Entre Rios, Paraná, Argentina.*

DOES *EUMECES FASCIATUS* (LINNAEUS) OCCUR IN FLORIDA?—A cursory examination of the records seems to indicate that *Eumeces fasciatus* should have Florida included in its range, but a closer scrutiny of the data on which the Florida records are based leaves room for some doubt. Taylor (1935, Revision of Genus *Eumeces*: 204) includes northern Florida in the range without comment. Florida was included in the range on the basis of nine specimens: Carnegie Museum nos. 1149, 1152, 1154, and 1155; Museum of Zoology nos. 53,059–61; and Academy of Natural Sciences of Philadelphia nos. 4083 and 9316. Through the kindness of Mrs. Helen T. Gaige, Dr. E. R. Dunn, and Mr. M. Graham Netting I have recently examined these specimens and believe there can be no doubt that they are *fasciatus;* however, there are some points concerning the data which are of interest. The specimens in the Carnegie Museum and the Museum of Zoology were received from Mr. Nat P. Fry with the data, "Marion County, Florida." Mr. Fry was a commercial dealer some years ago and had his business located in Marion County. There were no other *Eumeces* in the collection sent to the Museum of Zoology, but the collection sent the Carnegie Museum contained two *inexpectatus* and four *laticeps.* Dr. A. F. Carr, Mr. O. C. Van Hyning, and Mr. E. Ross Allen have collected assiduously in Marion County in recent years and have failed to procure a single specimen of *fasciatus.* It does not seem reasonable to believe that a person could be fortunate enough to secure several individuals of a form so rare that it has not been taken since without obtaining numerous specimens of the common species. This was at a time when they were not even recognized as being distinct. The other two specimens of *fasciatus* are in the Academy of Natural Sciences of Philadelphia with simply "Florida" given as the locality. They were presented to the Society in the 1890's by F. G. Schaupp and concerning them Dr. Dunn, in a letter, says, "I strongly suspect a dealer and pet keeper as the source of these specimens."

The presence of the species in southern Georgia suggests the possibility of its occurrence in Florida; however, until the meager evidence so far advanced is substantiated by the discovery or rediscovery of the species within our border I believe it should be omitted from the state list.—COLEMAN J. GOIN, *Department of Biology, University of Florida, Gainesville, Florida.*

THE SPOTTED NIGHT SNAKE *HYPSIGLENA* IN WASHINGTON.—During the annual field trip of the Department of Zoology of the University of Washington to the eastern part of the state, a specimen of the spotted night snake, *Hypsiglena ochrorhynchus* Cope, was collected alive from under a board at Vantage Ferry, on the east side of the Columbia River, on April 29, 1939. The specimen was normal in all characteristics except that the right eye was missing. The record from Vantage Ferry, Washington, is approximately 500 miles northward of its previously known range, and the species is an addition to the fauna of the state. Since Vantage Ferry is located in the hot dry sagebrush area of central Washington and this type of habitat continues to the southward into Oregon and Idaho, specimens from the intervening territory are to be expected. The specimen is in the vertebrate collections of the Department of Zoology of the University of Washington, Seattle, Washington.—ARTHUR SVIHLA and CAMERON KNOX, *University of Washington, Seattle, Washington.*

NOTES ON MISSOURI SNAKES.—An interest of several years in the reptiles of Missouri has led to the finding of two species of snakes not previously reported from the state, and to the discovery that records of another species frequently listed for Missouri are based on an incorrectly identified specimen.

Sonora episcopa (Kennicott)

A poorly preserved specimen of this species was given to me in 1935. It was said to have been found several years before, crawling among rocks in the evening, in McDonald County, Missouri, about two miles west of Noel.

On April 17, 1938, with Paul Anderson of Independence, Missouri, I visited St. Clair County, Missouri. About seven miles northeast of Osceola we collected seventeen specimens of *Sonora episcopa* on two hillsides about two miles apart. Six days later we collected seven more and on June 19 eight more specimens in the same locality. All were found under deeply imbedded rocks high on the south slopes of the hills at an elevation of about 750 feet above sea level.

The ground color of all of these specimens was quite red and all have a dorsal pattern of transverse black bars, about two scales in width, extending down the sides to the third, second or first row of scales, and, in some, extending onto the ends of the ventrals. All have 15 rows of scales, 7 supralabials, 6 infralabials, a single preocular and 2 postoculars. Temporals 1–2 in all except two specimens, in which they are respectively 1–2 and 2–2, and 2–2 and 2–3. The ventrals, in seven males, range from 144 to 149, caudals 41 to 48; in twelve females ventrals range from 148 to 160, caudals 32 to 40. The number of transverse dark bars on the body varies from 11 to 22, and the rings on the tail from 1 to 6. The largest male measures 296 mm., tail 60 mm.; the largest female 305 mm., tail 51 mm. The specimens have been deposited in the collection of the Chicago Academy of Sciences.

Heterodon nasicus nasicus Baird and Girard

While driving through southeastern Missouri on May 15, 1938, I discovered an injured snake of this species on the highway in Mississippi County, two miles south of Diehlstadt. On October 10, 1938, a return trip was made to this locality with Dr. H. K. Gloyd of the Chicago Academy of Sciences, and another specimen was found crawling through the sand in an open field at 3:30 P.M. two miles east of Diehlstadt in Scott County.

In the southern part of Scott County and the northwestern part of Mississippi County there is a flat, open, sandy area at an average elevation of about 330 feet above sea level, lying between the lower Mississippi River bottoms to the east and the higher ground of Sikeston Ridge to the west. The soil is the Lintonia Fine Sandy Loam and in places it is so loose that numerous "sand-blows" are formed. It appears to be an ideal habitat for this western snake and it seems possible that an isolated colony of these snakes, perhaps a relic population as suggested by Schmidt (1938, Ecology, 19: 404) in connection with his "steppe peninsula" hypothesis, inhabits this area.

The scutellation, number of dorsal spots, and measurements of the two specimens are as follows: CAS No. 8141, ♂, scale rows 23-23-18, ventrals 130, caudals 37, supralabials 8, infralabials, 10, oculars 10, temporals 3-4, dorsal spots on body 31, spots on tail 11, total length 385 mm., tail length 66 mm.; CAS No. 8142, ♂, scale rows 23-23-19, ventrals 132, caudals 42, supralabials 8, infralabials 11, oculars 10, temporals 4–5, spots on body 32, spots on tail 12, total length 470 mm., length of tail 85 mm.

Elaphe guttata (Linné)

When Hurter and Strecker wrote their *Amphibians and Reptiles of Arkansas* (1909, Trans. Acad. Sci. St. Louis, 18:11–27), they received a list of specimens in the Field Museum from Dr. S. E. Meek which included *Elaphe guttata* from Greenway, Clay County, Arkansas. They accepted this record and Hurter also included it in his *Herpetology of Missouri* (1911, Trans. Acad. Sci. St. Louis, 20:59–274) from which the following is quoted (p. 179): "Dr. S. E. Meek of the Field Museum of Natural History reports this snake from Greenway, Clay County, Arkansas. Clay County is just west of Dunklin County, Mo., and as the environments are the same, I do not doubt that eventually the Spotted Snake will be found in Missouri."

On the basis of this statement Missouri was later included in the range of *Elaphe guttata* in several publications.

At my request, the specimen from Greenway, Arkansas, was examined by Dr. H. K. Gloyd who found it to be a juvenile *Elaphe obsoleta obsoleta*. This is FMNH No. 535, collected in 1898. No collector's name is given but it was received by the museum from Dr. Meek and originally catalogued as *Elaphe guttata*. There is therefore apparently no evidence of the occurence of *Elaphe guttata* in Missouri.

Agkistrodon piscivorus (Lacépède)

The presence of the cotton-mouth in the lowlands of southeast Missouri has been well established for many years. Hunter, in 1897 (Trans. Acad. Sci. St. Louis, 7: 499–503), reported it from Missouri without giving a definite locality (probably Butler County), and in 1911 (*Ibid.*, 20: 59–274) he recorded it from Butler, Stoddard, and Dunklin counties. I have collected many specimens of this species in Stoddard County, the southern part of Bollinger County, and the southeast part of Wayne County, and William Holzmark, of St. Louis, collected one specimen on the St. Francois River in the Sam A. Baker State Park in Wayne County near Patterson. These snakes are usually found in this area in the cypress swamps, where they are plentiful adjacent to the rocky bluffs where they hibernate through the winter. They can be collected in large numbers in the spring and fall of the year on those hillsides having southern exposure.

There have been rumors, until recently unconfirmed, of the cotton-mouth in parts of the Ozarks, and it seems advisable to report some definite localities. Several years ago the head of a snake of this species was brought to the St. Louis Zoo for identification. It had been killed on the Meramec River in Crawford County, 8 miles east of Steelville. The residents of this vicinity describe a snake known to them as the "stub-tail" along Huzzah and Courtois creeks, tributaries of the Meramec River in Crawford County. The descriptions of appearance and habits fit the cotton-mouth very well, and in view of the Meramec River specimen, it seems quite probable that their reference is to this species. Until this year this was the only record of the cotton-mouth in the Missouri Ozarks known to me, except the specimen from the Sam A. Baker State Park, a locality only a few miles back in the hills from the swampy lowlands.

Early in the summer of this year Lisle Jeffrey, of the Missouri Conservation Commission, brought to the University of Missouri a cotton-mouth from Miller County. On September 13, 1939, about 11:00 P.M., I collected two specimens in Miller County in a small clear stream five miles north of Iberia. The first was found swimming across the stream, the other was coiled on the gravel bar at the edge of the water about 200 yards from where the first was collected. These specimens are in the museum of the Chicago Academy of Sciences (Nos. 8668 and 8669). This locality and the Crawford County locality are on the northern watershed of the Ozarks, and I believe are the only definite records of the cotton-mouth north of the Ozark plateau.

On the night of July 28, 1939, I was collecting with Kenneth Rowe, park naturalist of the Roaring River State Park, on Leatherwood Creek in Carroll County, Arkansas. This is a typical small Ozark stream flowing north into the White River, the mouth of the stream being near the point where the White River enters Barry County, Missouri. A cotton-mouth was collected on a pile of rocks by a riffle near the mouth of the stream. This is about one mile north of the town of Beaver, Arkansas, and about the same distance south of the Missouri line. The specimen is CAS No. 8616. It seems that this record would tend to confirm reports of this snake along the White River in the southern part of Barry County. Schwardt, 1938 (Bull. 357: Univ. Ark., College of Agriculture), reports "two specimens from the mountainous area of northwestern Arkansas." This probably refers to Washington County, which is included in the locality records of the same paper.

These localities extend the range of this snake to the north, but they should also be of considerable interest from an ecological standpoint, as the habitat in this region is quite different from that which has been recognized as typical for the species.—PHILIP D. EVANS, *6220 McGee Street, Kansas City, Missouri.*

DATES OF FROG CHORUSES IN FLORIDA.—For the past seven years I have accumulated notes on the choruses of frogs in the vicinity of Gainesville, Florida. The fall and winter of 1938–1939 have produced some unusually early records for first appearance of many of the local species.

From October 1, 1938, to March 1, 1939, I have had occasion to make regular nightly trips over the road from Gainesville to Lake Newnan, about 5 miles to the east. The flatwoods thus traversed is an open and monotonous pine-barren, burned over annually and heavily turpentined. The soil is chiefly Leon Fine Sand, in the terminology of the state soil survey, in which a relatively impervious hardpan near the surface greatly retards drainage. Undergrowth is sparse, consisting mostly of saw-palmetto (*Serenoa repens*), with some wire-grass (*Aristida* spp.) and scattered herbs. The area presents a variety of ponds and drainage ditches in which the smaller frogs breed. Most of our breeding records for northern Florida are based on observations made along this road, and visiting herpetologists in quest of frogs are always optimistically led to this area.

After a heavy rain (7.42 in.) on the night of October 23, 1938, *Pseudacris nigrita verrucosa* and *Pseudacris ornata* appeared in great numbers. These species usually breed from late November through March. It seems evident that temperature (above 32°–35°F.) plays little part as a stimulus or inhibitor to breeding in these forms. Extensive soaking of the soil, in which they apparently remain inactive during late summer and early fall, brings them out at all temperatures. A second breeding migration, in which both frogs were abundantly represented, is recorded below.

Fifteen to forty males of *Hyla gratiosa* were heard calling in each of five deeper, permanent ponds on the night of February 11, 1939. Conditions for the five days preceding were as follows:

Date	Precipitation	Range of temperature
Feb. 7	.68 in.	53°–74°
Feb. 8	.....	56°–81°
Feb. 9	.05 in.	66°–86°
Feb. 10	.....	68°–84°
Feb. 11	.....	65°–84°

I have recorded *gratiosa* as early as March 3 in former years.

On February 26, 4.40 inches of rain fell between 1 and 7 P.M.; maximum temperature for the day was 73°F., minimum, 67°F. At 10:30 P.M. the following frogs were observed:

P. n. verrucosa, P. ornata.—Numerous; several mated pairs collected; the second appearance for the season.

Bufo quercicus.—Abundant in several ponds. I never before found them breeding prior to April 1.

Bufo terrestris.—Very abundant. My earliest previous record for the breeding of this species is March 25.

Hyla femoralis, H. squirella.—Not observed in amplexus, but scattered males were calling in nearly all the ponds. Hitherto not heard until April 2.

Rana capito.—A few were heard in one pond. The gopher frog breeds throughout the year.

Pseudacris ocularis.—Very numerous, as after any heavy rain.

Acris gryllus and *Rana sphenocephala*, both quite ubiquitous and with breeding records for every month of the year, were absent on the 26th. For no apparent reason, both appeared in large numbers on the following night (precipitation, .05; temperature, 62°-86°F.).

On February 11, 26, and 27, at mid-day, three *Hyla v. versicolor* (possibly four on the last date) were heard calling in trees around a water-filled boat on the shore of Lake Newnan. *Hyla c. cinerea* was first heard, in scattered chorus, among the hyacinths along the lake-shore on the night of February 27. *Hyla crucifer*, whose rain-song and breeding call are apparently identical, has been heard nearly every night since October 23, chiefly in the swamp and hammock bordering the lake.—A. F. Carr, Jr., *Department of Biology, University of Florida, Gainesville, Florida.*

Reviews and Comments

NOMENCLATOR ZOOLOGICUS. A LIST OF THE NAMES OF GENERA AND SUBGENERA IN ZOOLOGY FROM THE TENTH EDITION OF LINNAEUS 1758 TO THE END OF 1935. Edited by Sheffield Airey Neave. [In four volumes.] Vol. 1, A–C; xiv + 957 pp. The Zoological Society of London. 1939.—The first volume of Dr. Neave's new nomenclator is out, and fulfills all expectations. It is a relief to have this compact and excellently edited work in place of the cumbersome, incomplete, and costly German nomenclator of Schulze. The new work includes the original citations for all names, the phylum in which each was proposed, and, *mirabile dictu*, cross references to substitutes proposed for preoccupied names. The reviewer notices extremely few errors or omissions on first perusal; the latter mostly concern common emendations or variant spellings. A few supergeneric terms, such as Cladistia, have crept in, and certain names eliminated by the *Opinions* of the *International Commission* (which by editorial policy were supposed to have been omitted) are present. But the errors are so few and the work so well done, up to date, and complete that its use is a pleasure.

There will be some surprises in this volume for ichthyologists and herpetologists. *Bufo* seems to have been proposed prior to Laurenti, 1768, *Barbus* appears to be preoccupied in birds, and *Chalcinus* definitely needs replacement. Some of these things were covered by Sherborn, but the present work should do even more to clear up generic nomenclature in all animal groups. It is to be hoped that zoologists will heed the Editor's warning (p. viii) against Strandian attempts to replace preoccupied names in phyla or families with the classification of which they are unfamiliar. The Editor asks zoologists to send him additions or corrections for inclusion in an addendum.

Neave's *Nomenclator* will henceforth be a necessary part of every taxonomic library, and every systematic worker owes considerable gratitude not only to Dr. Neave and his assistants, but also to the Zoological Society of London for its continued support, at heavy expense, of publications whose cost ought to be borne jointly by all institutions carrying on taxonomic work.—George S. Myers, *Natural History Museum, Stanford University, California.*

ELEMENTS OF STATISTICAL REASONING. By Alan E. Treloar. John Wiley and Sons, Inc., New York, New York, 1939: i–x, 1–253, 49 tables, 46 figs. $3.25.—The ideal fisheries student is a man well versed alike in biology and statistics. Unfortunately, such people are not common, good biologists often shying from mathematics, good mathematicians merely condescending to biology. For those of us who are more biologists than mathematicians, Treloar's book is an excellent text, presenting the fundamentals of statistics with amazing simplicity and clarity.

As the author says in the Preface, "Those who seek a compendium of statistical techniques, an array of formulas from which one or another may be culled to act as a mill for grinding fine flour from crude grain, merely by turning a handle, should not look further through these pages. What is written herein is intended for those who wish to reason carefully, not merely imitate. A sequence of such general concepts as seem to the author to be foundational is accordingly developed. From such a beginning it is believed that one may work forward to comprehension of the details of specialized procedures."—L. A. Walford, *Jordan Hall, Stanford University, California.*

KEYS FOR THE IDENTIFICATION OF THE FISHES OF THE GREAT LAKES AND TRIBUTARY WATERS. By Carl L. Hubbs and Karl F. Lagler. Published by the authors, Ann Arbor, Michigan, 1939: 1–37, 7 figs. $.50.—"This guide consists of a series of keys, the first to the families, and the others to the genera, species and subspecies in each family. The treatment has been made as simple as possible, without an undue sacrifice of the means for precise determinations. More complete characters may be found in the keys and descriptions of the publications cited in the Bibliography."

QUANTITATIVE ZOOLOGY. NUMERICAL CONCEPTS IN THE STUDY OF RECENT AND FOSSIL ANIMALS. By George Gaylord Simpson and Anna Roe. McGraw-Hill Book Company, New York, 1939: xvii+414 pp., 52 figs. $4.00.—The reviewer has long awaited a book on statistics written by a naturalist for naturalists, stubbornly refusing to believe that his difficulty in attempts to apply statistical methods to problems in taxonomy and comparative anatomy was entirely due to his peculiar shortcomings and lack of mathematical background. *Quantitative Zoology* vindicates this view, which no doubt was shared by many others in a field where analysis of scale counts and comparative measurements looms large. The application of statistical methods to natural history studies becomes intelligible in the able hands of these authors. There probably is not a vertebrate taxonomist who could not profit from reading the second chapter, which deals with the significance and limitations of the measurements used in taxonomic work.

One of the most significant and gratifying phrases in the book is found in the preface: "This text presupposes no knowledge whatever of statistics, and of mathematics no more than elementary algebra." The sympathetic, though never patronizing, viewpoint of the authors softens such obviously true accusations as that zoologists "have, in fact, been dealing with some very subtle and difficult numerical concepts, but too often they have failed to recognize them as such, and frequently this has resulted in their serious misuse."

The interests of the senior author are in themselves a guarantee that the specific needs of naturalists would receive adequate emphasis, nor is it surprising that paleontology should figure prominently throughout the book. Many of the examples used for illustration have been drawn from ichthyological and herpetological literature, however, and the authors were obviously fully familiar with the peculiar statistical requirements of these fields. It is curious, nevertheless, that Klauber's statistical studies of the rattlesnakes, which so far as the reviewer is aware are the only frankly statistical studies in herpetological literature, were apparently completely unknown to Simpson and Roe.

The book contains no tables other than summary tables scattered through the text. An appendix gives simple instructions for using calculating machines (although their use is not presupposed in the text), a list of the symbols used in the text, with their meaning, a list of formulas for handy reference, and a useful glossary of statistical terms. There is an extensive annotated bibliography, with purely mathematical references and selected zoological references that contain examples of the application of statistical methods, listed separately. Emphasis in the index is rather curious. All casual references to authors are faithfully listed, for example, but such an important statistical operation as the chi-squared test must be found by hunting through the text.—D. Dwight Davis, *Field Museum of Natural History, Chicago, Illinois.*

ZUR ENTWICKLUNG DER EXKRETIONSORGANE VON DIPNOERN UND AMPHIBIEN MIT ANMERKUNGEN BEZÜGLICH GANOIDEN UND TELEOSTIER. By Märtha Kindahl. Acta Zoologica, 19, 1938: 1–190, 120 figs.—The position of the lung-fishes in zoological classification is of so much interest and importance as to have afforded a classical problem in comparative anatomy. This was long regarded as solved, in favor of direct relation with the fishes, all of the amphibian characters being explained as due to convergent evolution.

The question of a possible direct relation with the salamanders has been revived in recent decades from both embryological and paleontological evidence. Thus Säve-Söderbergh, in 1936, proposed a new classification of the Anamnia, in which the group Caudata is derived from the lung-fishes and other Amphibia are thought to be derived independently from stegocephalian ancestors. Pursuing the embryological side of the evidence, following Holmgren, Miss Kindahl presents a detailed account of the comparative embryology of the excretory organs of various fishes, of the African and Australian lung-fishes, of *Triturus* and *Necturus* for the Caudata, and of *Xenopus, Alytes,* and *Rana* for the Salientia. Her conclusion, that the conditions observed support the independent origin of the Caudata and Salientia from fish-like ancestors seems to be valid enough. American herpetologists and ichthyologists alike will feel that the contrary evidence has not been sufficiently weighed. Romer briefly alludes to the questions at issue in his *Vertebrate Paleontology* (1933: 92).—Karl P. Schmidt, *Field Museum of Natural History, Chicago, Illinois.*

LIFE, HEAT, AND ALTITUDE—PHYSIOLOGICAL EFFECTS OF HOT CLIMATES AND GREAT HEIGHTS. By Davis Bruce Dill. Harvard University Press, Cambridge, 1938: XIV + 211 pp., 25 figs.—Most of this book, based on a series of eight lectures prepared for the Lowell Institute, deals with human physiology, presenting the results of modern investigations on the effects of hot climates and of great altitude on the normal physiology of energy exchange. Chapter V, on Animal Life in Deserts, is of interest to readers of COPEIA for its brief account of experiments on the relations of lizards to environmental temperatures. The cloacal temperature of a chuck-walla, confined in the sun, rose rapidly above the level of the air temperature; the lizards began to display distress at about 44° (the air temperature being 38°); a desert tortoise died with a rectal temperature of 45°; a horned toad survived after its rectal temperature had reached 49°, recovering when removed to a cool room. I note a curious slip in the statement that the jerboa of the deserts of southwestern Asia is closely allied to "*Zapus*" of the Colorado Desert. *Zapus* should read *Dipodomys;* but *Dipodomys* is by no means a close ally of the jerboa.—KARL P. SCHMIDT, *Field Museum of Natural History, Chicago, Illinois.*

A GUIDE TO THE FISHES OF TENNESSEE AND THE MID-SOUTH. By Eugene R. Kuhne. Tennessee Department of Conservation, Division of Game and Fish, Nashville, Tennessee, 1939: 124 pp., 81 figs., 25 cents.—This useful book pleases the reviewer not a little. It is not a complete monograph on the fishes of Tennessee, but includes all of the species, even to minnows, in which the citizens of Tennessee are likely to be interested. There are good but simple keys to the families, most of the genera, and some of the species; an adequate number of usable illustrations (mostly from photos); a selected bibliography; a glossary and figures explaining terms; a short chapter on collecting and preserving specimens, and places to send the specimens for identification; and an introduction stating plainly what the book can and cannot do. The classification and nomenclature is as modern and correct as possible. This book proves that a popular handbook can be reasonably accurate scientifically.—GEORGE S. MYERS, *Natural History Museum, Stanford University, California.*

ANGLING IN AMERICA. By Charles Eliot Goodspeed. Houghton Mifflin Co., 1939: xiv+365, several plates. $15.00.—This book is a history of fresh water angling in America with particular, if not exclusive reference to the states east of the Mississippi. It treats of men who, for one reason or another, are still remembered for their fishing exploits—they may have written books, or founded sporting clubs, or developed tackle; and it treats of famous and historic angling places, societies, practices, books, and even relates a few of the more distinguished fishing yarns. Enthusiastic anglers will find the book an agreeable reminder of familiar places and persons. Antiquarians will be pleased to have so complete a compendium, for the book not only brings together material that was hitherto available only in scattered and obscure sources, but it contains an excellent "selective short-title check-list" of pertinent works ranging from 1660 to 1900.

In format, the book is a collector's piece, handsomely printed and illustrated. There is an excellent index.—L. A. WALFORD, *Stanford University, California.*

NEW BOOKS RECEIVED

STUDIES OF THE FISHES OF THE ORDER CYPRINODONTES XVI. A REVISION OF THE GOODEIDAE. By Carl L. Hubbs and C. L. Turner. Misc. Publ. Mus. Zool., Univ. Mich., 42, 1939: 80 pp., 5 plates. $.90.

A CONTRIBUTION TO THE HERPETOLOGY OF FLORIDA. By Archie Fairly Carr, Jr. Univ. of Fla. Publ., Biol. Sci. Ser., 3 (1), 1940: 118 pp. $1.35.

FURTHER EXPERIMENTS IN THE BREEDING OF OYSTERS (*OSTREA EDULIS*) IN TANKS. By H A. Cole, Great Britain, Ministry of Agriculture and Fisheries; Fishery Investigations, Ser. 2, 16 (4), 1939: 47 pp., 15 figs. 2 s. 0 d. (about 40c).

A BIBLIOGRAPHY OF NATURE STUDY. By Eva L. Gordon. Reprinted from Anna Botsford Comstock's Handbook of Nature-Study, Twenty-Fourth Edition. Comstock Publishing Company, Inc., Ithaca, New York. 1939: 863–908 pp. 25c.

EDITORIAL NOTES AND NEWS

Western Division Meeting

THE WESTERN DIVISION, ASIH, will hold its annual meeting in Seattle, Washington, in June. An especially large attendance is anticipated, since this year the Pacific Division, AAAS (with which the WESTERN DIVISION meets), and the Southwestern Division are meeting jointly with the national organization of the American Association for the Advancement of Science. The dates are June 17–23, 1940.

There will be two general sessions (one day) for the presentation of papers. Five herpetological and ichthyological exhibits (at the School of Fisheries) will be displayed. A field trip to the commercial fish establishments on the Seattle waterfront is planned. In addition plans have been made for a one day symposium (two sessions) on "Salmon Problems along the Pacific Coast of North America" in which the directors of all the salmon investigations from Bristol Bay to the Sacramento River (including British Columbia) have been invited to participate. The President, DR. W. M. CHAPMAN, and the Local Committee desire that the talks will center on the problems and methods of attack rather than be a record of accomplishment. A lively discussion is anticipated for the salmon question is an important public issue in the West, and is equally interesting to the non-specialist and the specialist.

The Seattle Local Committee follows: DR. LOREN DONALDSON, Chairman; DR. RICHARD VAN CLEVE; PROF. ARTHUR SVIHLA; MR. A. C. DELACY; and DR. W. M. CHAPMAN, President, WESTERN DIVISION, ex officio.

Editorial Notes

THE SECRETARY reports that the Society has on hand 30 complete sets, with indices, of the Old Series of COPEIA, numbers 1 to 173, 1913 to the beginning of 1930. These sets are available at $34.00, which represents a saving of one-third under the cost of the numbers if purchased individually. When these sets are sold, it will no longer be possible for the Society to offer complete sets of the Old Series. The New Series, 1930 to date, 4 numbers per year, is sold without discount at the regular subscription rate of $3.00 per year, or $30.00 for the years 1930–1939 inclusive. Orders should be sent to the Secretary.

The 1940 meeting of the Society will be held as scheduled at Toronto, Canada, September 2 to 4, overlapping by one day the meeting of The American Fisheries Society which is scheduled for September 4 to 6.

The editors wish to remind the members of the Society that changes of address should be reported promptly to the SECRETARY.

Financial aid in publishing this issue of COPEIA was furnished by DR. W. H. RICH.

The recent retirement of the Chief of the Bureau of Marine Fisheries of California's Division of Fish and Game has created a vacancy that offers an excellent opportunity for those qualified in this field. A competitive civil service examination for this position was scheduled by the California Personnel Board through its executive officer, Louis J. Kroeger.

The position pays a starting salary of $320 per month and the entrance requirements for the position include education equal to that represented by graduation from college with specialization in biology, zoology or marine fisheries and extensive, that is, more than five years experience, in fisheries research and major research projects, or an equivalent combination of education and similar experience.

The work includes directing a staff engaged in a program of research for conservation and management of marine fisheries of the State of California, and coordinating the general work of the Bureau with other divisions of the Fish and Game Commission.

Definite information as to the exact date of the examination can be obtained by writing to the State Personnel Board, 1025 P Street, in Sacramento, California.

Pacific Coast Aquaria

THIS list of aquaria on the Pacific coast was compiled at the suggestion of DR. TRACY I. STORER largely through records kindly loaned by Mr. Alvin Seale. It is published at this time with the hope that it may prove useful to members planning to drive to the WESTERN DIVISION, ASIH, June meeting in Seattle, announced elsewhere in this issue. For convenience the aquaria are listed from south to north. FW indicates that the exhibit is largely of fresh-water (usually tropical) fishes. No attempt has been made to list all commercial houses maintaining displays. We have no recent news of the San Clemente or Catalina Island aquaria, nor of any in British Columbia. Travelers should keep in mind the new Dallas, Texas, Aquarium, as well as those in Honolulu and Manila.

The San Francisco Aquarium Society meets on the first Thursday of every month except July and August at 8 P.M. at the Steinhart Aquarium, Golden Gate Park. Visitors are always welcome.

CALIFORNIA

La Jolla: Aquarium, Scripps Institution of Oceanography
Corona del Mar: Kerckhoff Marine Laboratory
Los Angeles:
Weber's Tropicarium, 12855 Ventura Blvd. FW
Weinberg Aquarium, 120 North Gale St. FW
Lloyd's Hollywood Aquarium FW (some marine)
Santa Monica: Aquarium, Santa Monica Pier
Pacific Grove: Hopkins Marine Station (seasonal)
Santa Cruz: Santa Cruz Aquarium, City Wharf
Daly City: Tropiland, 428 Santa Barbara Ave. FW
San Francisco:
Aquarium Supply House, 2735 Geary St. FW
Frank Locke, 232 Pt. Lobos Ave. FW
Nippon Goldfish Co., 1919 Bush St. FW
Steinhart Aquarium, Golden Gate Park
Crescent City: Crescent City Aquarium

OREGON

De Poe Bay: De Poe Bay Aquarium
Seaside Beach: Seaside Aquarium

WASHINGTON

Steilacoom: Deep Sea Aquarium
Tacoma: City Aquarium, Point Defiance Park
Seattle:
Frozen fish exhibit, Port of Seattle Spokane St. Cold Storage Plant
Deep Sea Aquarium, Pier 3
Palace Fish and Oyster Co., Coleman Dock
Univ. of Washington: Dept. of Oceanography School of Fisheries (seasonal)
Friday Harbor: Friday Harbor Oceanographic Laboratories

Recent Deaths

DR. WILFRED WELTER of the Morehead State Teachers College, Morehead, Kentucky, was killed in an automobile accident December 25, 1939. Though Dr. Welter will be remembered chiefly as an ornithologist he was interested in fishes, also, and contributed last year a paper on Kentucky fishes for COPEIA.

Corrections

N COPEIA (4), 1939, the following corrections should be made: In the Table of Contents, delete Elden H. Vestal, Mating posture in the Alligator Lizard (*Gerrhonotus coeruleus*); change page reference under Clyde L. Patch, Northern Forms of the Wood-Frog, to 235. On page 199, read Shanulin Laboratory of Biology, Wesleyan University, Middletown, Connecticut. On page 230, in first two entries of tabulation, read 11:25 and 11:28 for 12:25 and 12:28. On page 241, in line 6 of first paragraph and line 4 of second paragraph read Vice-President Gloyd for Vice-President Dymond.

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Original contributions, not to be published elsewhere, are alone acceptable.

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Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author, at the discretion of the Editors.

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